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PRODUCT ENGINEERING

JULY
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Modern design calls for instruments scientifically selected and built-in. How German and American designers do it and how instruments and process controllers are selected, is told in three articles

Mechanical Design • Product Development

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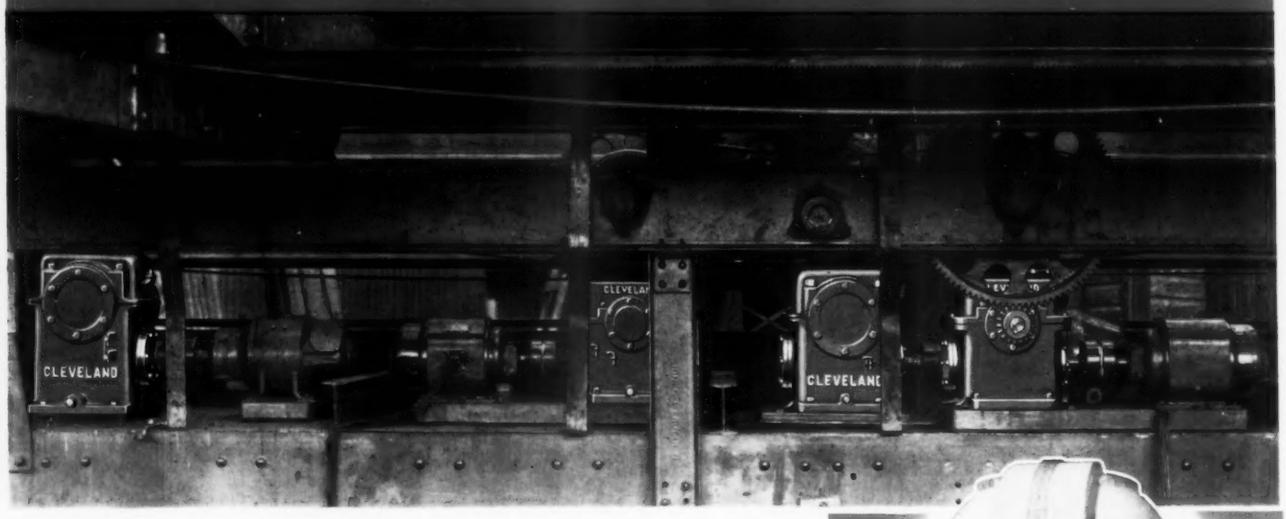

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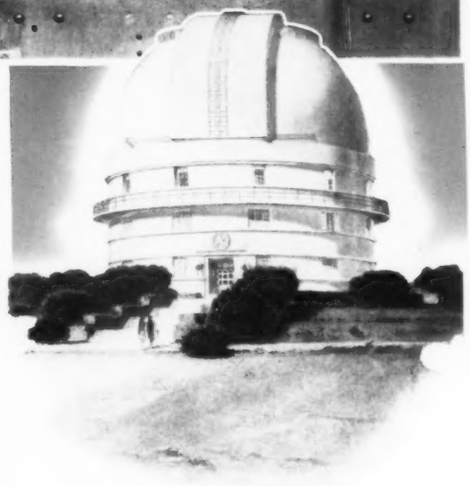

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PRODUCT ENGINEERING

VOLUME 6 NUMBER 7

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Next Month

"Lubrication of Chain Drives," will conclude the present series on the design of chain drives. This article will give data based on the results of extensive tests and will explain what type of lubrication is best for given conditions, and how to apply it.

Howard Ketcham will continue his color articles, and as a fitting companion there will be a three-page article on the coloring of aluminum, a process that has made considerable progress over the past two years.

Other subjects covered in the August number will include a simplified method for determining the paths of points in mechanisms, designation of surface qualities, by Lieutenant Commander R. J. Walker of the U. S. Navy, and a two-page spread of typical automotive bearing mountings.

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Intimate Correspondence

What is the American Economics Foundation?

PRODUCT ENGINEERING
NEW YORK

I was much interested in the editorial that appeared in the May number of *Product Engineering* entitled "Shall Patent Laws Be Scrapped?" Being a patent attorney, my first interest was to find out who or what the American Economics Foundation might be. What might be their motive in sponsoring legislation that would so evidently interfere with the wonderful progress we have been making in the development of new ideas and inventions? Evidently, this organization receives backing from some source or other to defray their expenses. I therefore concluded that if I could find out who are the backers of the American Economics Foundation it would be an easy matter to judge their motives and real objectives.

Strange as it may seem, telephone calls to most of the persons whose endorsement of the foundation appears in their literature revealed that they do not know who are the backers of the foundation. Also, all the efforts of a dozen men of high standing in their respective fields were unable to secure from Percival White, director of the foundation, the names of any of the backers. One member of the advisory board, when approached, stated that he is not at liberty to disclose the backers.

I wonder if *Product Engineering* could assist me in securing the desired information.

—C.S.M.
Patent Attorney

WE print the above in the hope that some of our readers might throw some light upon this serious subject. One report suggests that A.E.F. is a "publicity stunt" to sway public opinion relative to the present RCA-Philco controversy over royalty payments. We judge it is at least something of such a nature. At any rate, present indications are that a least a half dozen susceptible college profs gave their endorsement to a "cat in a bag."

We Sure Slipped

PRODUCT ENGINEERING
NEW YORK

Engineers are supposed to be conservative and likewise engineering publications should also be conservative. I have always considered *Product Engineering* to be a dignified, conservative publication, but you sure did slip in the June number. In the article "Design Proportions for U-Leather Packings" you started right off with the sentence, "Leather is the only material that has a satisfactory life under high hydraulic pressures." There is no point in arguing this sentence because we all know it is not true. And it does not take a technical expert to know it —R.F.C.
Chicago, Ill.

THIS is not the only letter we received concerning the sentence referred to. In our Questions and Comments department we publish another one. Our only explanation for the glaring error is that we are human.

Shock Loads and Opinions

PRODUCT ENGINEERING
NEW YORK

Could you give us some articles about chain drives for withstanding shock loads such as are developed in tractor service? Also information about combinations of materials in gears best suited to withstand shock loads in tractors would be valuable in this field because there is a large difference of opinion as to the factors of safety demanded. —C.E.S.
Greenwich, Ohio

THIS letter arrived too late to be published last month. Although not in as great detail as C.E.S. would like to have, the third of the series of articles on chain drives, appearing in this issue, contains some discussion of shock loading. As for gear materials, we would like to hear from more of our readers.

More On Construction Machinery

PRODUCT ENGINEERING
NEW YORK

You at one time ran quite a number of articles relative to brakes and clutches such as used on construction machinery. Data on construction equipment is especially interesting to me and I am wondering if we can't have more such articles. —E.E.M.
Ravenna, Ohio

OUR reader is evidently harking back to several articles written for *Product Engineering* by A. C. Rasmussen. We will endeavor to satisfy this request.

Not Missing

PRODUCT ENGINEERING
NEW YORK

I wish that you could arrange to have articles under "New Materials and Parts" and the two-page spreads showing standard construction, which is missing in the May issue, in such a way that clipping and filing will not damage other interesting reading matter. —O.E.C.
Rochester, N. Y.

THE two-page spread on standard construction did appear in the May number on pages 190 and 191. We must admit, however, that this spread looks unusual because of the relatively large amount of descriptive matter that was necessary. Hence it lacked the appearance of the usual spread.

As for the arrangement to make it possible to clip the pages without destroying other interesting reading matter, we have sandwiched the standard construction pages beween the Question and Comment department and the News department, because we believe that the material in those two departments is mainly of only passing interest. Are we wrong in this?

Suggestions Wanted

PRODUCT ENGINEERING
NEW YORK

As a suggestion, it would be a fine thing if you could get someone to give you one or more articles on designing of hydraulic turbines and the laying out of core boxes for such turbines. While it is true that this is a specialty and there are only a few builders in the country, there are people who are interested, even if they do not happen to be turbine designers. —C.E.K.
Watertown, N. Y.

ALTHOUGH we have not had any articles dealing specifically with hydraulic turbines, we wish to call attention to the fact that the series of articles on the lateral vibration of shafts, written by Lewis F. Moody, consulting engineer for Baldwin-Southwark, related primarily to hydraulic turbines. Of course, there are many other fundamental engineering problems in the design of hydraulic turbines. Has anyone any suggestions?

Flash!

PRODUCT ENGINEERING
NEW YORK

Under your "Intimate Correspondence," in a recent number, mention was made of a mechanically operated flashlight, with the statement that no such light is at this time manufactured in the United States.

Although, in so far as we are concerned this statement is literally true, you will no doubt be interested to know that we have perfected a light of this type. It is only a matter of finding a suitable manufacturer who might be interested in the manufacture and sale of this device in order to put it on the market. —S.F.M.
Washington, D. C.

WE ARE interested to know that such a flashlight is available for manufacture in the U. S. and we certainly hope that S.F.M. will soon find a suitable manufacturer. If any of our readers are interested we will be glad to forward their inquiries.

PRODUCT ENGINEERING

GEORGE F. NORDENHOLT, *Editor*

MCGRAW-HILL PUBLISHING CO., INC. JULY 1935 VOLUME SIX, NUMBER SEVEN

The Science of Colors

IN THE beginning of every new era or period there will always be found the "die hards" who stubbornly stick to the old school. And there are also those who honestly disagree or cannot comprehend the new regime, its reasons for existing or the basis for its operation. Thus it is with the new science of selection of colors.

As a rule, mechanical designers are supremely practical. Hedged about with the innumerable problems that must be solved in creating a technically perfect product, it is not surprising that they often shun the task of color selection. Indeed it can hardly be expected that men highly skilled in mechanical design should be possessed with an ability for color selection. A few are so endowed but they are exceptions.

Although an artistic sense is one of the requisites, it must not be concluded that this is the only basis for color selection. The science of color is quite well established and many studies have revealed the various psychological effects of different colors. Every color possesses hue, value and chroma. Colors in combination affect one another. Not only do colors have an emotional effect but often they also exert a definite influence on physical reactions.

An intelligent understanding of the science of color is within the grasp of every engineer. Such an understanding enables one to appreciate the task of those who specialize in color selection. It makes possible better cooperation between the mechanical designer and color engineer or industrial designer.

Another usual result of a proper understanding of the fundamentals that underlie the science of color is a realization that color selection by other than experts is likely to lessen the salability of the product. In some instances the selection of wrong colors has had disastrous results. Specific examples are cited in the series of articles by Howard Ketcham beginning in this issue.

Color selection is both an art and a science. Quoting Raymond Loewy, "The fact that a color is good does not mean that it will sell. It is just that some colors click and others do not." And in discussing the selection of colors for railroad trains, Otto Kuhler states, "Today we are more color conscious than ever before and just as color has helped the sale of other products and services, we may reasonably well expect that it will do likewise in the railroad field. But I also wish to warn the inexperienced color enthusiasts that the psychological reaction to color may either do a selling job or be repulsive."

There is little room for arguing the above statements, and one is forced to conclude that the best color effects can be obtained only when the final selection is left in the hands of an expert. A proper understanding of the science of colors will do much to foster this conviction.

Built-In Meters and Gages As Original

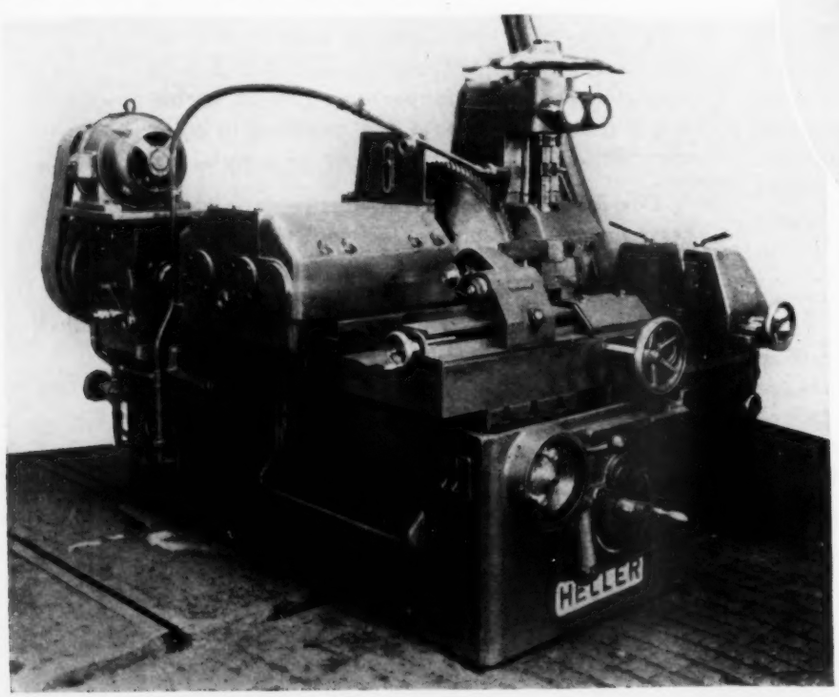
A survey of the increasing trend toward built-in counters, tachometers, temperature indicators, ammeters, gages and similar instruments, with examples of the better operating convenience and efficiency and the improved appearance of American and German machines

IN PLANNING this study of the application of instruments to machines, it was felt that much could be gained from a first-hand investigation of German practice. It has been generally known that German designers have been placing special emphasis on machine instrumentation. And in view of their reputation for thoroughness, it was thought that their developments in this field would be worth investigating. Therefore, Kenneth H. Condit, editor of *American Machinist*, former editor of *Product Engineering* and now its consulting editor, made a special point to study the German practice in the application of instruments to machines when he toured industrial Germany last April.

Space permits a description of only a relatively few of the many striking examples of machine instrumentation uncovered in visits to the plants of leading German machinery builders. But all of the examples described have a number of features in common. In general, German designers equip their machines more completely with instruments. In each instance, the instruments are built-in as an integral part of the machine. The dials, electric pushbuttons and control levers are grouped in a panel whenever such an arrangement contributes to the convenience of operation. Special attention is evidently given to the positioning of the dials so that they can be read by the operator without shifting his position. Other features are apparent in the pictures and descriptions given here.

One example of German machine instrumentation is the Heller automatic cold saw shown in Fig. 1, manufactured by Gebr. Heller of Nuertingen, Germany. In this machine the work is clamped between hydraulically operated vise jaws. The saw feed is also hydraulic, operating in the same hydraulic system as the vise jaws.

Fig. 1—Flush-mounted built-in gages are well protected and improve the machine appearance and operating convenience



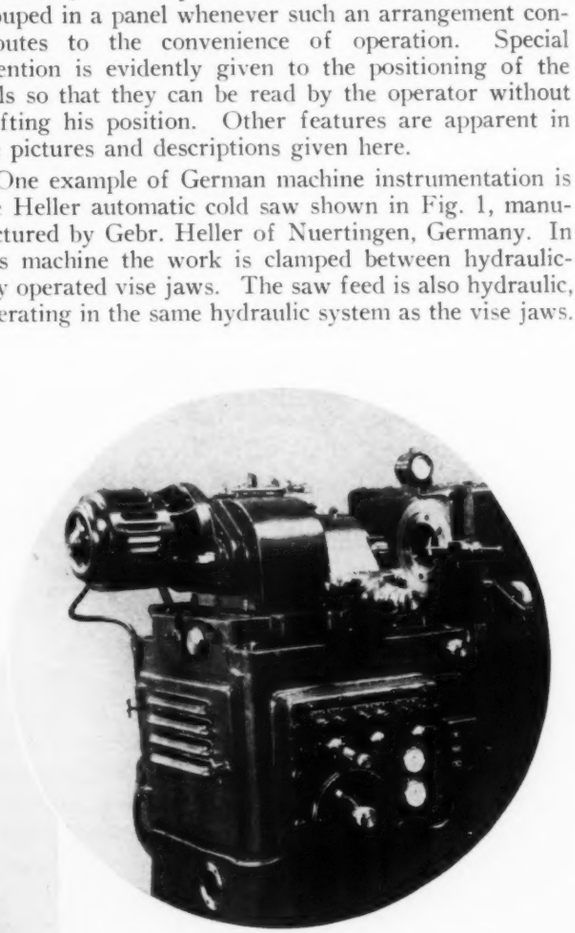
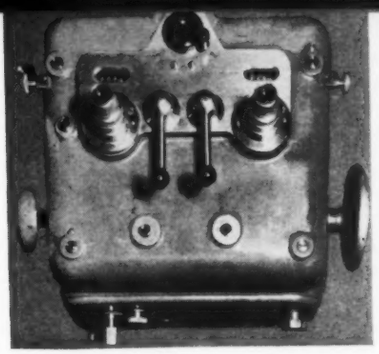
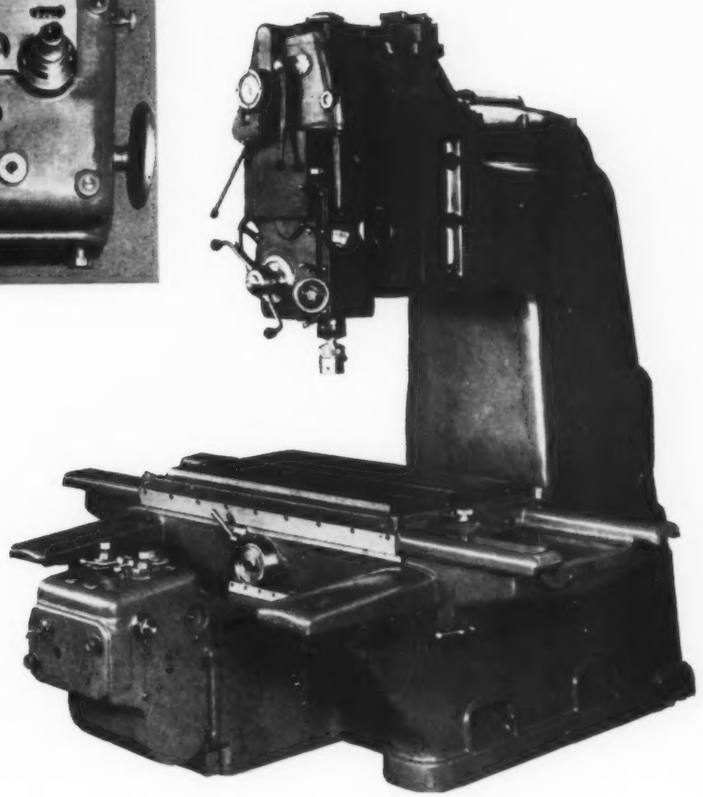


Fig. 2—Gage on top of the housing indicates the lead of the thread being milled





Equipment

Hence as the feed pressure increases, the clamping pressure also increases. This assures rigidity of the work under the heaviest cut. The hydraulic feed pressure of the saw against the work and the clamping pressure at the vise are indicated on two built-in pressure gages mounted in the machine frame above the upper vise jaw. These pressure gages are placed so that they are at the eye-level of the operator and are about in line with his vision when he is watching the cutter.

A good example of the grouping of gages and controls in a single panel is seen in the Heller hydraulically operated thread miller shown in Fig. 2. It will be noticed that on top of the spindle housing is a separate isolated gage. This gage indicates the lead of the thread being milled and is placed so that it will be in the field of the operator's vision when he is watching the cutter. The gage is actuated by a push rod attached to the cutter head.

With d.c. motor drives it is usually necessary to equip the machine with a tachometer in order that the machine can be run at the proper speed. Whereas in a.c. synchronous motors the speed is fixed within narrow limits without regard to the load, in d.c. motors the speed will be determined by the load-speed characteristics of the motor for the given setting of the field rheostat. Thus for most efficient machine operation it is necessary to have some check on the spindle speed, this being adjustable within the range of the motor by manipulation of the field rheostat.

Fig. 3—Cutter heads of Köllmann planer-type milling machine, driven by d.c. motors, have tachometers to indicate the spindle speed

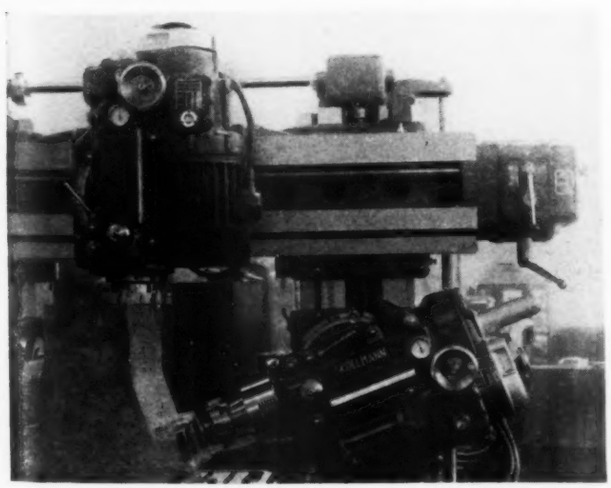


Fig. 4—In the Herbert Lindner jig borer a tachometer indicates the spindle r.p.m. The auxiliary view of the control panel shows the pushbuttons, switches and microscopes for setting the table

In the Köllmann planer-type milling machine shown in Fig. 3, manufactured by the Köllmann Werke A.G. of Leipzig, Germany, each of the three cutter heads is equipped with a built-in tachometer which registers the r.p.m. of the spindle. The tachometer dials can be seen mounted flush in the spindle housing. Exact cutter speed can be maintained readily by manipulation of the field rheostats, thus enabling the operator to run the machine at the most efficient cutting speed.

Another feature of the Köllmann planer-type milling machine is the feed indicating dial. Three gear shifting levers position the feed gears for any one of 24 finely stepped feeds, the lever positions for the various feeds being given by a chart mounted on the face of the gear box. Flush mounted in the face of the gear is a dial gage that indicates the feed per revolution for every position of the three gear shifting levers.

A similar application of built-in tachometer for measuring cutter spindle r.p.m. and feed indicating dial is found in the Lindner jig borer shown in Fig. 4. It is manufactured by Herbert Lindner A.G., Wittenau, Germany. In addition to the tachometers and feed indicating dials this jig borer is equipped with two sets of counters, scales, built-in lights and microscopes for setting the table transversely and longitudinally.

The insert picture in the upper left corner of Fig. 4 is a top view of the control panel located at the front of the machine. The two pushbuttons shown at the lower part of the control panel are for forward or reverse rotation of the longitudinal and transverse feed

motor, as determined by the position of the lever switch in the upper part of the panel. As the table moves its position is registered to the nearest 0.1 in. by the automatic counter. When the desired position to the nearest 0.1 in. has been reached further adjustment of the table is made by hand. The operator looks into the microscope, depresses a button which illuminates a finely divided scale in the field of the microscope, and sets the table to the desired position by turning a hand-wheel. In this way he is able to set the table within 0.0001 in., both in the longitudinal and the transverse position.

A further step in both a.c. and d.c. motor driven machines is to equip them with an ammeter to indicate whether or not the machine is being operated to its full capacity. Not only will the ammeter indicate whether or not the most productive feed and speed is being used, but it will also show an increasing load as the tools become dull. An example of such an application is the Schmaltz radius grinder for automobile die parts, shown in Fig. 5. The ammeter is built into a case mounted on the bed, which case also contains the push-button station for controlling the motors for grinding wheel positioning, wheel rotation, wheel speed and coolant pumps. The ammeter and switches are grouped for convenience of operation.

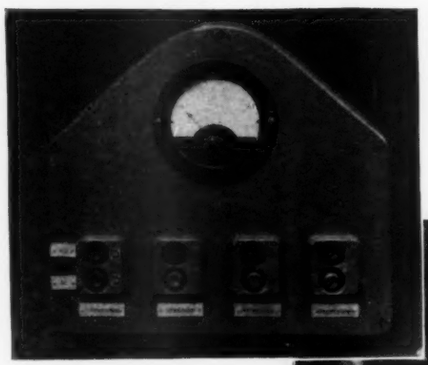


Fig. 5—(Left) Control panel with built-in ammeter to show load on the machine and if tool is getting dull

In addition to the instruments and devices for checking and controlling the machine operations, more attention is being given to built-in gages for controlling the accuracy of the machine output. In the Ingersoll bucket-type milling machine, designed especially for General Electric Company for machining turbine parts, a built-in gage indicates the size to which the work has been machined. As can be seen in Fig. 6, these gages are mounted in the stationary part of the cutter spindle housing. A rod fastened to the spindle quill carries a pusher that operates the dial indicator.

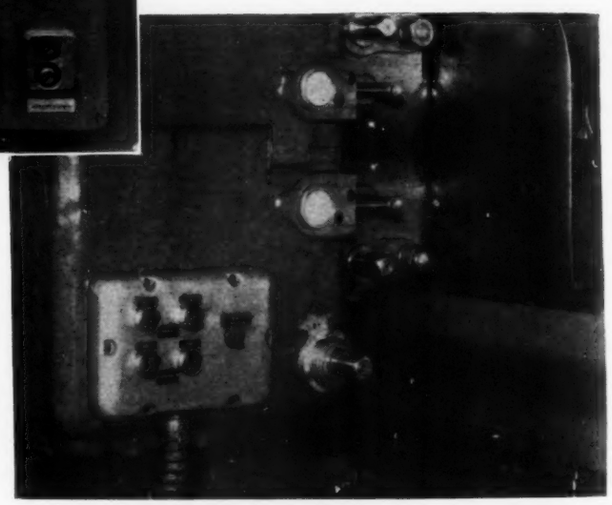
A similar application of dial indicators is shown on the Jones & Lamson comparator. A built-in indicator in conjunction with spacing blocks makes possible accurate longitudinal setting of the table. The lower gage for vertical measurements is mounted on a bracket, as shown in Fig. 7, and is used in a similar manner. When not in use, the indicators are protected by a hinged cover.

In some machines for high-precision finishing, the gaging of the work must be done with extreme care. For economy, the time required for taking measurements is, to an increasing extent, accommodated within the machining time. For this reason, built-in gaging devices are applied to the machine. These function automatically while the machine is in operation and do away with the need of removing the work or stopping the operation.

One German manufacturer, Siemens-Schuckert, has developed a device which indicates kilowatt hours and elapsed time on two separate dials. This instrument is mounted into a flanged frame, having a hinged cover, the whole unit being inserted into an opening of the machine bed, thereby giving a flush appearance.

Not all machines lend themselves to built-in gages. The hydraulic leather press shown in Fig. 8, built by Watson-Stillman Company, is a good example. Here the gage is simply put into the hydraulic system. It is evident from the picture of the machine that there would be little point in building-in this gage.

In production machines the counting or measuring of output has become an important factor. Little need be said concerning the possibilities of built-in counters other than to point out that whereas these in the past have been purchased and mounted by the user of the machine, the present trend is for the manufacturer of the machine to incorporate the device as a part of the



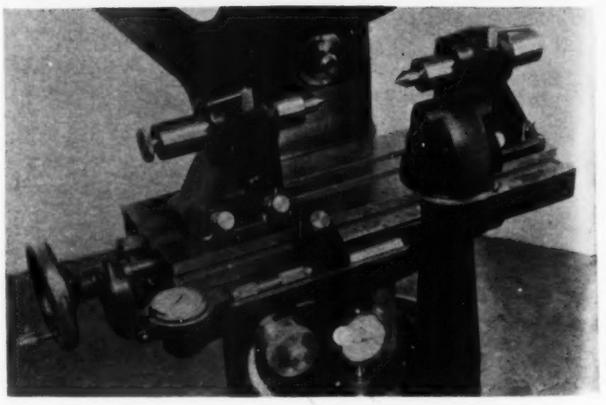


Fig. 6—(Above) Ingersoll milling machine with dial gages to indicate sizing of work. Fig. 7—(Below) Jones & Lamson comparator equipped with dial gages for setting table

original equipment, building it in to the best advantage.

There has been considerable development in the design of counters since the day of the first cyclometers used on bicycles and the counters on reciprocating steam engines. From these simple counters there have been developed counters that measure length, geared counters, resetting counters in various forms, magnetically operated counters for remote recording, and numerous other types. All of these various counters are available in a variety of cases and for various mountings. Special counters are designed for special services. Perhaps the most remarkable development in counters is the computer designed by the engineers of the Wayne Company in cooperation with the engineers of Veeder-Root. This device, (described in *P. E.*, Jan., 1934) not only records the exact number of gallons delivered by the gasoline pump but also records the cost of the gasoline delivered as well as showing the price per gallon at which the device is computing.

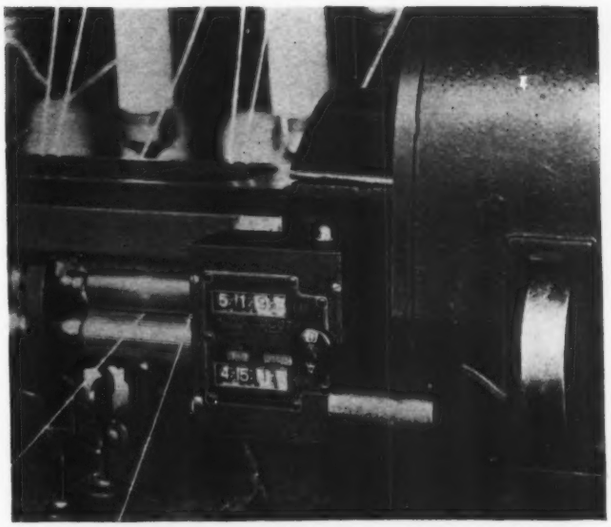


Fig. 9—(Above) Veeder-Root counter for recording day and night-shift production, as applied to a textile machine

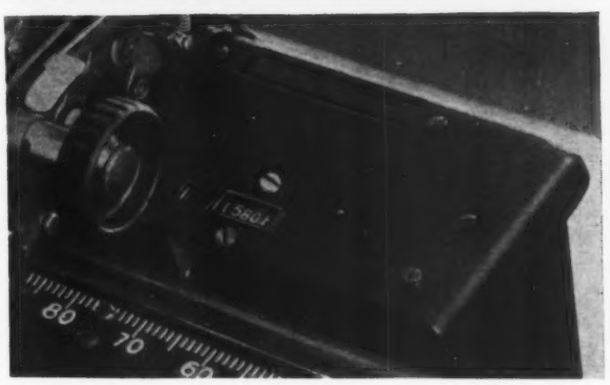


Fig. 10—(Below) Royal typewriter equipped with a Veeder-Root counter specially designed for building into the machine

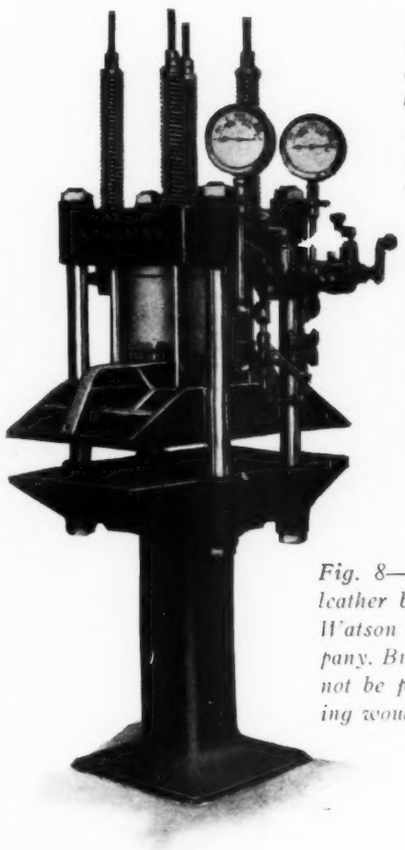


Fig. 8—(Left) Hydraulic leather belt press built by Watson-Stillman Company. Built-in gages would not be practical and nothing would be gained

In Fig. 9 is shown the design of the Veeder-Root hank counter mounted on the machine frame. The feature of this counter is that it can be set for day-shift or night-shift production.

An interesting example showing what can be accomplished when the application of a counter is properly engineered is shown in the Fig. 10. Devices for counting the number of lines typed have long been used on typewriters. The customary method has been to attach a standard counter at the rear of the machine, the counter being operated by a suitable lever. This arrangement was not entirely satisfactory as it necessitated the operator to walk around the desk in order to read the figures. To overcome this on the Royal typewriter, a built-in Veeder-Root counter is used. This counter is placed under a cover on the right-hand side of the machine and can be read from the front, the operator being able to read it from a sitting position.

Almost invariably there are a number of definite improvements when the counter, gage or other instrument is incorporated as a unit part of the machine. Usually more intelligent attention is given to the selection of the device, with the result that the one selected is more suited to the requirements. And whereas the machine user generally attaches the accessory in the simplest and most convenient manner, the designer of the machine will apply it so that the instrument or device will operate most efficiently, be protected and tamper proof, and will improve appearances.

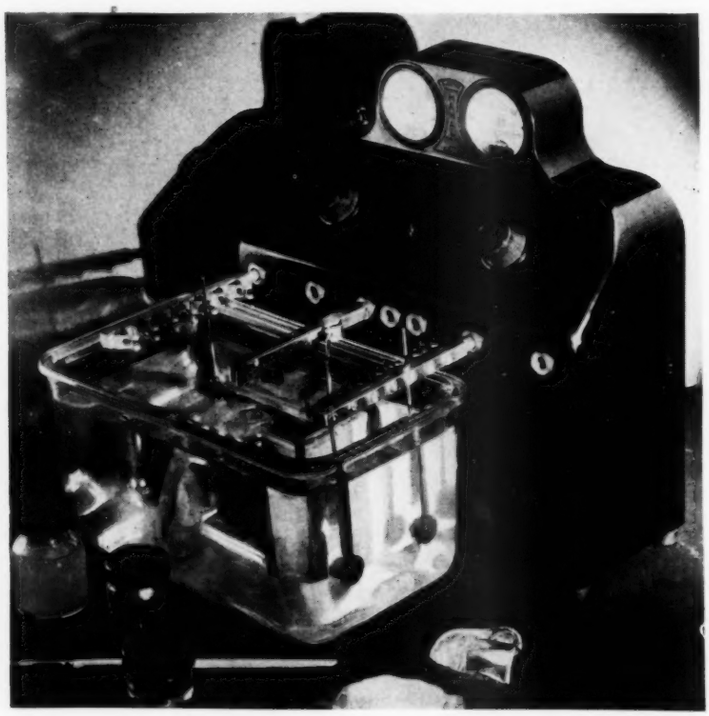
At first thought it might appear that the built-in devices will cost more than attached standard devices. There is, of course, the necessity of providing a housing and suitable connections. But when the instrument housing is designed as a part of the machine it is necessary to purchase only the instrument mechanism which is mounted directly into the housing. In a number of instances special counters built from combinations of standard parts have been found to cost less than the completely assembled standard device.

PRODUCT DEVELOPMENTS

Molded Plastic Cabinet For Electroplating Unit

● Metal bases for artificial dentures have many advocates in the dental profession because of their hygienic advantages and their excellent thermal conductivity. Heretofore metal bases were produced by the casting or the swaging process, either of which involved laborious techniques and considerable expense. It was also found that the models of teeth or gums, usually made of plaster or artificial stone, lack the desired accuracy. By the new method, the metal models are produced by electrolytic deposition of copper or other metal upon the impression taken in the mouth. This accurate metal model subsequently serves for the electrolytic forming of a silver base. To this silver base, after gold and rhodium plating, the porcelain teeth are attached with vulcanite or any other material now used for such purpose.

In the new Hanau plating unit for forming metal denture plates by electrolytic deposition, the cabinet for housing the controls and ammeters is a phenolic plastic molding. A number of considerations decided the choice of this material.



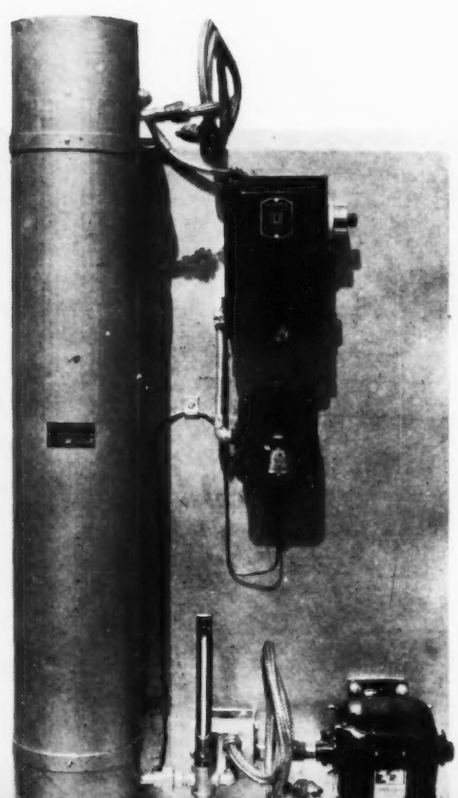
New Hanau electro plating unit has molded plastic cabinet and exposed metal parts are stainless steel

According to the Hanau Engineering Company, the shape is too intricate for a metal stamping and it is so large—more than 12 in. high—that a die-cast metal case would have been heavy. Also, if made of metal extra electrical insulation would have been required and the acid in the electrolytes would attack metal. On the other hand, the acids have no effect on the inert phenolic plastic case, there is no possibility of its luster wearing off, the case is light and strong and it will not corrode or check. Nor will the material warp when wetted by the plating solutions. The material is Durez, molded by Norton Laboratories, Inc.

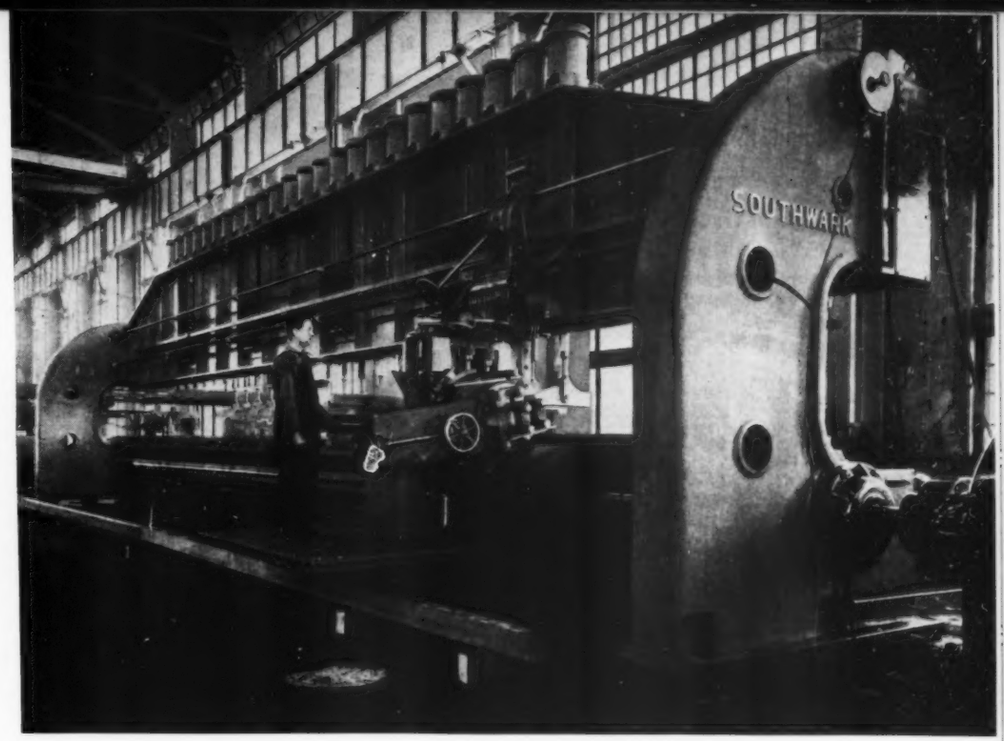
All exposed metal parts are made of stainless steel, thereby making the unit completely corrosion proof.

● *Oil Heater With Adjustable Controls*

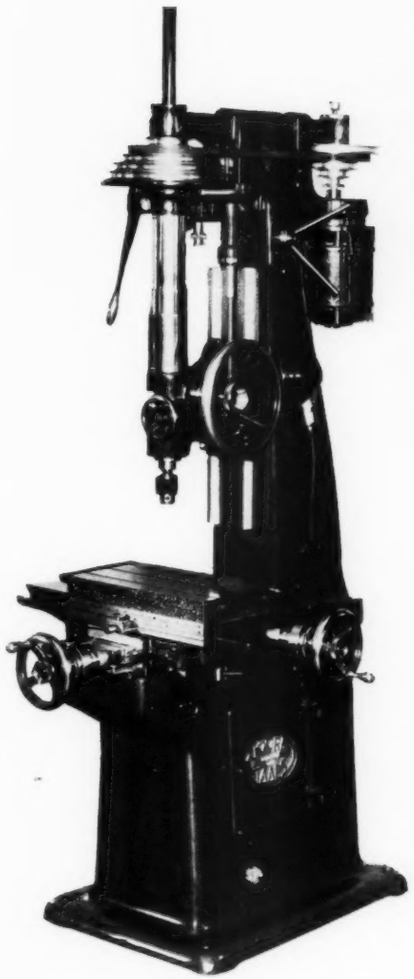
In the molding of synthetic materials and in the making of die-castings, the dies work better when they are kept hot with a supply of heat independent of the molding or



Automatically controlled Trent heater for circulating hot oil around molding and die-casting dies



One feature of this Baldwin - Southwork plate planer is a quintuple threaded drive screw, 7 in. in diameter, 58 ft. long



Integral lighting unit completes the product. Moore Special Tool Company provided this machine with both power and light outlets and put all wiring inside, thereby making a clean neat job

casting process itself. With heated dies there is no possibility of the molding material being chilled or the dies cooling off before the finished work can be taken out.

A new design of electric heater for furnishing preheated oil to be circulated around dies has been developed by the Harold E. Trent Company. As shown in the accompanying picture, the oil storage tank, electric controls, temperature regulator and motor-driven pump are all mounted to form a single unit. The oil tank has a heavy jacket of heat insulation. Inside the steel tank is an immersion type electric heating unit. The lower end of the oil tank is piped to a gear-type pump directly connected through a flexible coupling to electric motor.

At the top of the panel can be seen the main control box below which is the adjustable regulator.

• *Heavy-Duty Planer*

Designed to plane edges of plates up to 36 ft. long and 4.7 in. thick and make 18 in. scarfs along the edges of such plates, the planer shown in the accompanying picture has a number of unusual features. It was built by the Baldwin-Southwark Corporation.

Hold-downs of this planer are pneumatically operated and clamp the plate with a total pressure of 120 tons. A 50 hp. motor drives the machine, all controls being operated from the tool carriage on which the operator rides. Pressure lubrication is used and all important wearing surfaces are hardened steel.

Cutting speed is variable from 15 to 45 ft. per min., cuts being made on both directions of travel of the tool carriage, the drive screw of which is 7 in. in diameter and 58 ft. long with a quintuple thread and mounted on roller bearings. The cutting of this screw presented a number of problems.

Tool feed is from 1/128 in. to 1 in. per cut. Maximum vertical adjustment of the tool is 10½ in. and the horizontal adjustment is 24 in.

• *Random Jottings On Bills of Materials*

Jenkins Brothers now offer valves with the wheel of colored molded plastic—blue, red, black, green and gray. In addition to being of distinctive color the wheels are available with any of five standard service markings molded in relief. Special colors or markings are also obtainable. Advantages claimed are that these wheels are strong, cool to the touch, easy to grasp, sanitary and permanent in color.

Aluminum spider bases for swivel chairs are being die-cast in one piece by Doehler Die Casting Company. One operation does the whole job. The walls are thin and reinforced by ribs where necessary, giving a light base.

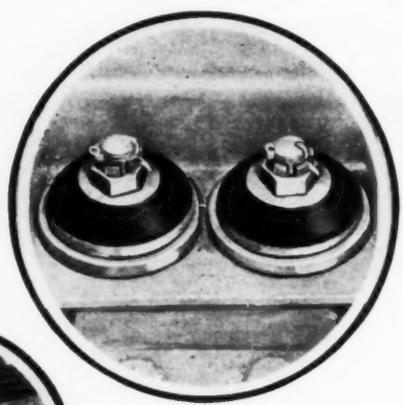
To take the guess work out of controlling the welding pressure, Thomson-Gibb equip their welding machines with a "Pressure Meter" which controls and indicates the pressure being applied at the welding points. Once the best pressures for an entire range of work have been determined, it is a simple matter to set the machine to operate at the correct pressure, as indicated by the gage on the meter.

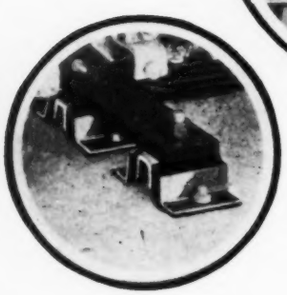
What is claimed to be the largest d.c. fan-cooled motor was recently completed by Reliance Electric & Engineering Company. Totally inclosed, 125 hp., 300 r.p.m., motor is 7 ft. 6 in. long, weighs 14,000 lb. Lincoln Electric Company was con-

sulted on the design of the arc welded frame which is made of 2-in. rolled steel plate. Channels for cooling air are formed by ¼-in. steel plate welded to the frame. Cast steel feet are also welded to the frame.

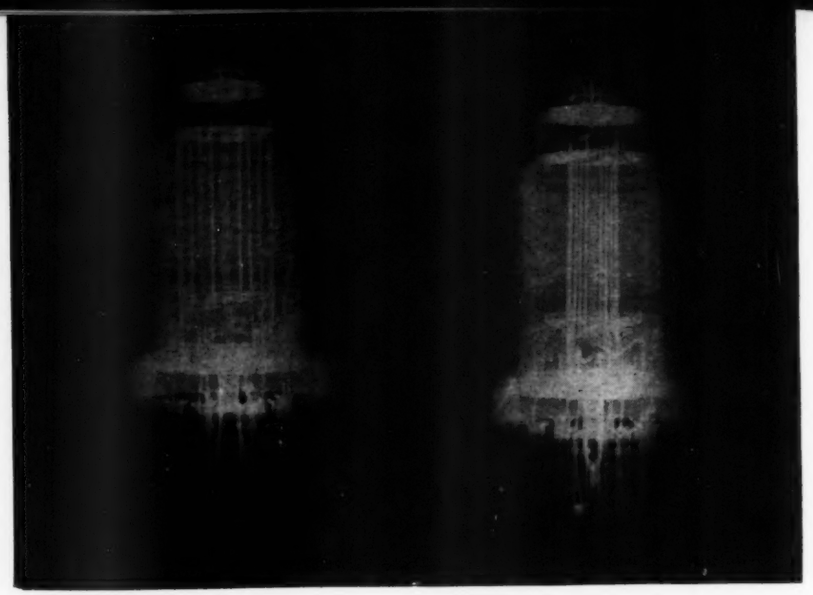
Glass valve seats are an exclusive patented feature of the hand pumps made by F. E. Myers & Brothers Company. The flanged glass seat is held in a fitting by a nut and rubber rings cushion the glass against nut and fitting. Valve disk is rubber; thus both valve and disk are corrosion resisting.

Use of manganese steel for crane and hoist sheaves is increasing. To simplify machining problems, Timken Roller Bearing Company has developed a new design of roller bearing mounting which permits sheave hub to be bored straight through at a single setting. Double cup bearings are pressed into hub, located by end caps, adjusted by shim. Cup may also be located by snap rings or depend upon its press fit for location.





Rubber mountings—the "biscuit" for bolt connections and the rubber - in - shear bracket



(Above) Metal radio tubes, assembled by welding, are inspected by X-rays to show up all details of the internal structure. (Below) In this die-cast shock absorber, rotation of the piston moves it axially, also giving large volume displacement

• *Rotor Piston For Shock Absorber*

Because work done is equal to pressure times change in volume, in order to use low working pressures in automobile shock absorbers, which is desirable, the design must permit a large volume displacement of fluid for a small angular movement of the arm of the device. In the new shock absorber of the Bridgeport Hardware Manufacturing Corporation this is accomplished by a "rotor-piston" which moves axially in the cylinder when rotated by the splined rotor shaft which has a sliding fit through the center of the rotor.

In the accompanying picture can be seen how the threaded periphery of the rotor piston engages threads on the inside wall of the cylinder, thereby causing the piston to advance axially when it is rotated.

Machining and production costs are reduced to a minimum by the use of zinc alloy die-cast cylinder sleeve, piston and shaft splines. Merely a broaching process is required for final finishing.

• *Hollow Motor Shaft*

In the portable mixer designed by the Patterson Foundry & Machine Company, the motor shaft is hollow to receive the solid propellor shaft. The motor is of standard construction, except the one end bell which serves as the supporting housing for the stirring shaft. This end bell is extended and has an oversize ball bearing to support the shaft.

A considerable length of the solid stirring shaft extends into the hollow motor shaft, thus assuring good alignment. Adjustment for the shaft length can be made without tools, a split ferrule being inclosed within a tapered adjusting nut. It is always quickly and easily released by the turn of the hand, as is the motor mounting clamp which is operated by a wing nut, thereby eliminating the necessity for tools.

• *Invisible Assemblies Inspected by X-Rays*

In the manufacture of the new metal radio tubes by the General Electric Company no appreciable trouble is encountered because of defective welding. The Thomson-Gibb seam welders used are Thyratron controlled, the metal container for the metal tube being welded to the header with a single application of current.

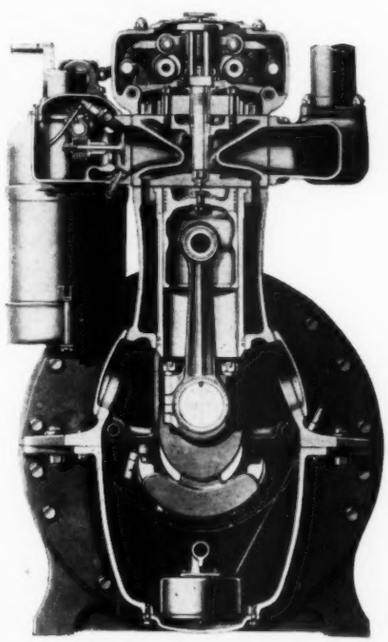
The mechanism of the weld is as follows: The upper electrode descends into the header and holds the embossed projections against the flange on the shell, on the bottom of the header with a definite resilient pressure. A current passed through the electrodes heats the metal to a fusion temperature. Since the upper electrode is held down with either spring or pneumatic pressure, the instant the pieces of metal become plastic, they are forged together, completing the weld. The duration of the flow of current is accurately controlled from one-sixtieth to one-twentieth of a second, depending upon the thickness of the material being welded.

With these short welding times only the projection is heated. The tubes can be immediately lifted from the electrodes and handled with bare hands, so little has the temperature been raised. The speed with which the parts can be loaded and unloaded is the factor limiting the output per welding machine. With dial feed, 30 welds per minute can readily be obtained.

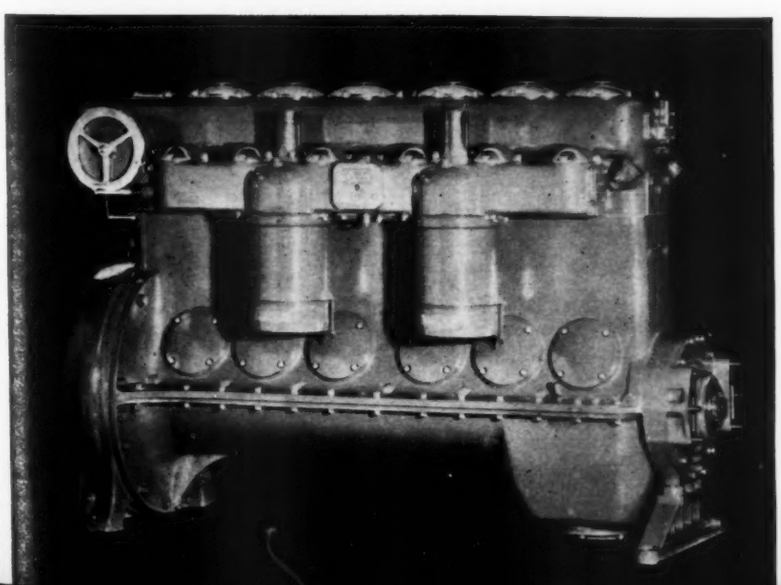
In welding machines for this class of service it is important that the machine be designed to give consistent welds. The motion of the top electrode should be such that it does not hammer and mushroom on the down stroke. Since high peak currents are required the reactance of the electrical system must be kept low.

Defective welds in metal radio tubes are so rare as to be of no consequence. But it is necessary to check the relative position of the different elements inside the finished tubes. This was formerly done by cutting away a portion of the sheath, the tubes thus inspected being no longer salable. About 2 per cent of the tubes were inspected in this manner. This entailed a considerable loss and was not conclusive as to the correctness of the remainder of the tubes.

The only solution to this problem was X-ray inspection by the flouroscopic method. As can be seen in the accompanying picture, the X-ray shows up all the details of the internal structure, wiring, spacing and alignment in the same size and relation as exists in the tube.



The new design of fuel system of the Murphy diesel combines pump and nozzle, eliminates high-pressure fuel lines, and is actuated by two overhead camshafts driven from the flywheel end

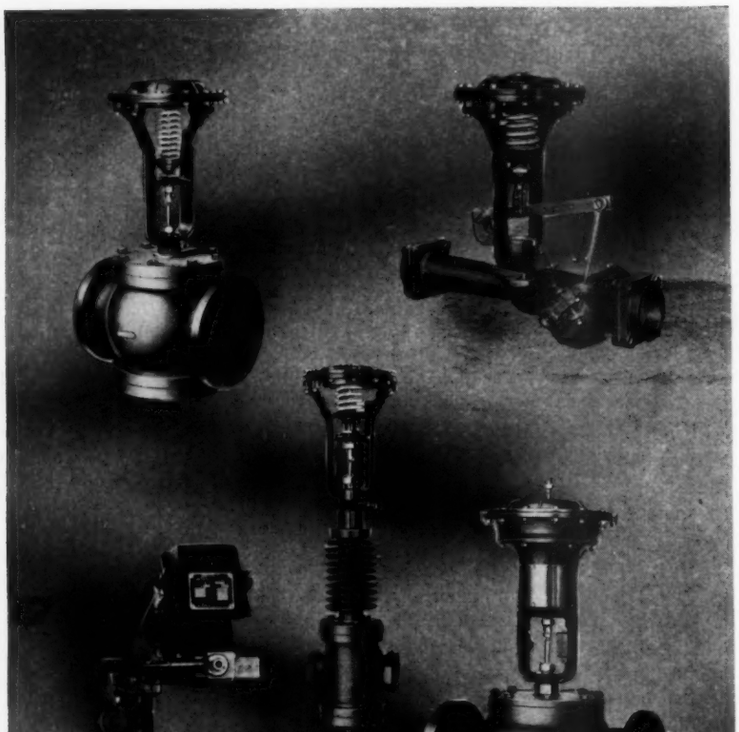


• *New Murphy Diesel Has Many Refinements*

A new fuel injection system, better starting, extremely sensitive governing, and balanced drive are featured among the improvements in the new diesel engines designed by the Murphy Diesel Company, Ltd. It is a $5\frac{3}{4}$x$6\frac{1}{2}$ six-cylinder unit for industrial and marine service.

In the fuel system of this new diesel the fuel pump and nozzle are combined in a single injector unit placed in the center of the cylinder head. It is actuated directly by two camshafts, one on each side, thus giving a balanced drive. Oil under 10 lb. per sq.in. pressure is delivered to the injector, the pressure of the fuel entering into the combustion chamber ranging from 2,000 lb. per sq.in. at idling speed to 4,500 at maximum r.p.m. This pressure exists only at the tip of the injector. Thus all high-pressure fuel lines have been eliminated throughout the engine.

Other features of the new Murphy diesels are: gasoline starting with this auxiliary fuel burned within its own combusion chambers; oil tight and dust tight construction to assure greatest cleanliness with incidental reduction in wear; water pump and oil pump mounted directly on the crankshaft, thermostatic controls that hold lubricating oil and cooling water temperatures within 20 deg. of each other; oil-bath Donaldson-type air cleaners built into the inlet manifold to form an integral part of the engine; fly-ball type governor controlling an hydraulic servo motor which keeps speed variations from full load to no load within a variation of less than one per cent.



Automatic

Applications for automatic process controls, and the speed of response, sensitivity and adaptability of air and electrical systems for controlling pressure, temperature or complete process cycles

Air-operated and motorized control valves made by The Bristol Company for automatic control of temperature or pressure

MANY processes today require greater accuracy in controlling temperature, pressure and time than can be obtained by human effort. By the use of controlling instruments, the designer can assure proper functioning of the machine, largely eliminating the variable human element. Instruments can be made as sensitive as required, and can perform a number of simultaneous functions.

Losses from spoiled material are reduced, production is greater and quality is higher and more uniform when automatic process control is built into the equipment. In such machinery as food and chemical equipment, die casting and molding presses, and in textile dryers, enameling and baking ovens, and heat-treating furnaces purchasers are recognizing the increased value of automatic process controls. But the application of automatic process control is so intimately associated with the design of the machine that the selection of the control equipment is essentially a design problem rather than a problem for the machine user.

In applying automatic temperature controls, each of the three elements—the control instrument, the sensitive element and the controlling device—present different problems which must be considered together in the design to obtain best results. Factors entering into the selection of the type of control instrument are described in the article "Temperature and Electrical Measuring Instruments," beginning on page 262 in this number.

Heat flow conditions in the process determine the position of the temperature-sensitive element. Differences in temperature between various parts of the heated chamber or portions of the batch being processed, whether the material is flowing or being stirred, the thermal lag of the entire control system and similar factors must be considered. The temperature-sensitive element must be placed in the path of flow of the heated material. Although the sensitive element does not necessarily have to measure the exact temperature being controlled, the element must be located where the temperature measured is at all times proportional to the controlled temperature.

Operation of devices controlled by temperature-sensitive instruments requires a separate source of power when precise temperature control is needed. Either air- or electrically-operated devices are available, both capable of the same sensitivity and accuracy. Such factors as speed of response, convenience in connecting the device to the instrument, and the type of controller used ordinarily are the important factors entering into the selection of the operating medium.

Speed of response in air-operated systems depends upon the length of the air line as well as the characteristics of the controller. For operations in which an integrating control is needed a slow speed response can be obtained readily. Where high-speed response is necessary, electrically operated devices used in com-

Controls for Pressure and Temperature

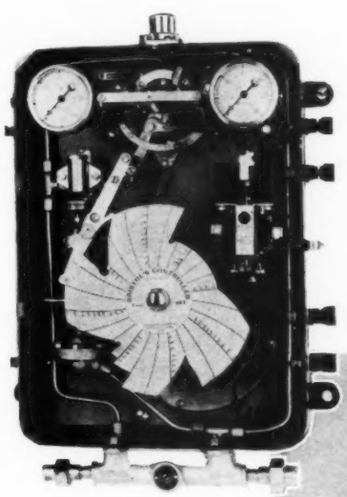
bination with a fast-acting controller will result in a minimum time lag. The greater convenience of electrical wiring over pipe lines in some instances will favor the selection of electrically-operated mechanisms. Electrical leads can be placed in pipe conduit used for other wires or cored channels in the machine can be used. However, in installing air lines along irregular paths, a threaded pipe line can be replaced by copper tubing connected with compression or soldered fittings. For either pipe or copper tubing the bore should be $\frac{1}{4}$ in. for ordinary service, or larger for rapid operation. Normal operating pressures are 15 lb. per sq.in.

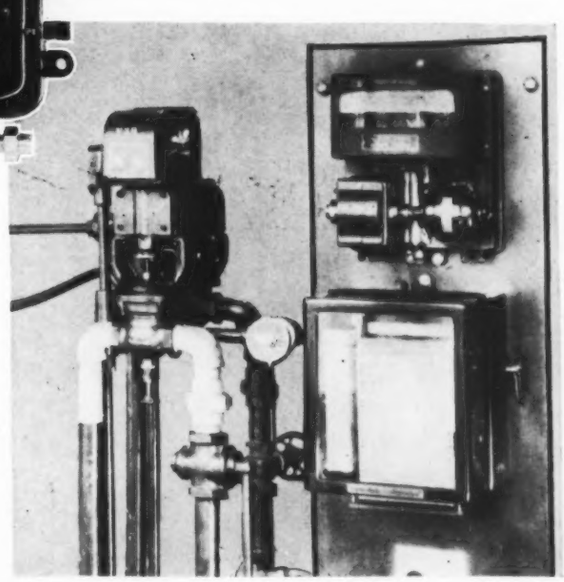
Where electrically-operated controlling instruments are used, a convenient source of energy for the control device is already available. For temperature-control instruments of the pressure type, no electrical supply is required for the instrument, and compressed air lines usually available may be more convenient than an electrical power source. Air-operated mechanisms usually require a low pressure—normally 25 lb. per sq.in.—with the pressure regulated by a reducing valve. Filters and dryers in the air supply line are usually needed to obtain reliable operation of the air-operated controllers. When electrically-operated control devices are required, pressure-type instruments are available with commutators or mercury switches.

Air-operated mechanisms usually obtain motion from a diaphragm or bellows. For on-and-off devices the type of expansion member used depends on the length of stroke and such service conditions as temperature, corrosion and frequency of operation.

For a short stroke the diaphragm type of expansion member is more compact than a bellows. The diaphragm is made of leather or a rubber compound reinforced with fabric for service at normal temperatures. The diaphragm material is usually supported by an external spring so that the diaphragm serves only as a flexible seal. For service temperatures above 200 deg. F., metal diaphragms are required, and for short strokes the metal diaphragm may replace all or a portion of the spring element. For long strokes a metal bellows is ordinarily used without a supporting spring when operating loads are low. Where a higher thrust is needed, a bellows having a larger diameter is supplied, with a supporting helical spring placed within the bellows. The formed metal bellows when made of brass or bronze can be used at temperatures up to 400 deg. F., while still higher temperatures are permissible with other bellows materials such as stainless steel or Monel metal. High operating temperatures can be reduced under favorable conditions by supporting the expansion chamber on a radiating, finned section of the type illustrated on the preceding page.

For greater accuracy than can be obtained with on-and-off temperature controls, throttling or floating control devices are available in which the air pressure admitted to the diaphragm or bellows is adjustable to any





(Left) Process cycle controller governing heating and cooling rates as well as length of time at any temperature. (Below) A single motor simultaneously operates two valves under control of the Bristol instrument

intermediate pressure. In these floating controls special constructions are necessary to eliminate "hysteresis" or the difference in position for identical closing or opening pressures. Since the force available for operation is relatively small, friction and imperfect elasticity in both the diaphragm and spring are possible sources of hysteresis. For applications where precision operation is essential, special types of floating controls are available with low hysteresis.

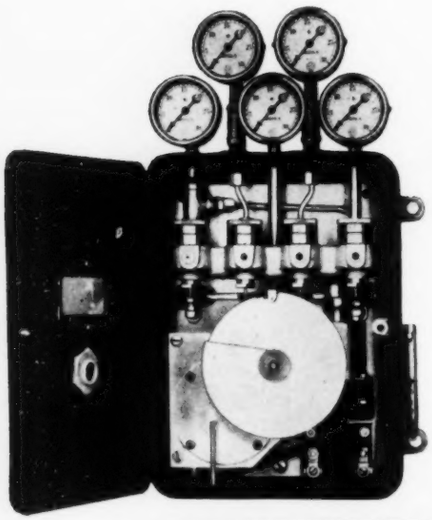
Air-operated devices are obtainable direct acting—closed with pressure against the action of a spring—or reverse acting—opening with pressure. For some applications a double diaphragm type offers the advantage of dual control, making it possible to combine two separate sources of control. In a double diaphragm air-operated valve for example, one of the diaphragms can be connected to a temperature controller while the other is connected to a time controller to maintain a given temperature for a definite length of time. Other modifications of these air-operated devices are available for proportioning controls in which a single controller operates two or more diaphragms, or a single diaphragm operates two or more devices.

All of the types of functions obtained from air-operated controls can be obtained by electrically-operated mechanisms driven by small electric motors or solenoids. Or intermediate relays connected to the control circuits can energize motors, clutches, electrical heaters or other power equipment. In selecting the type of electrical device, such factors as the work required, characteristics of the current supply and the rating of the controller circuits must be considered. In devices operated by small electric motors geared to a crank or rotating shaft, the speed of operation, torque required at the output shaft and the frequency of operation are important factors also.

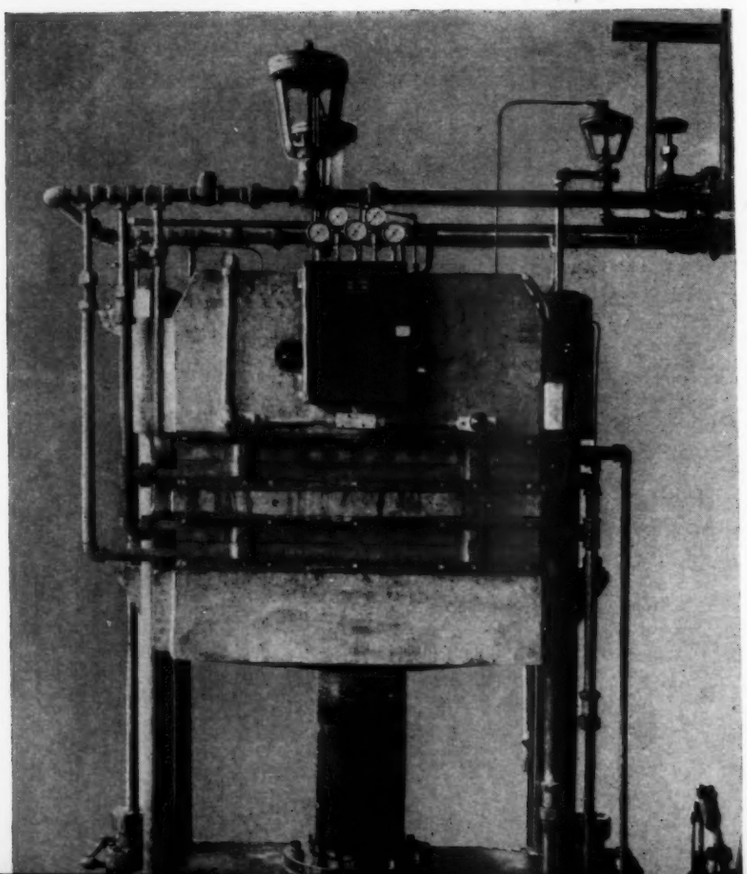
In many processes more than one temperature is required during the process cycle, and the time of operation must be controlled concurrently with pressure or temperature. In such applications complete instrument control of the process will be doubly effective in improving the performance of the equipment.

Instruments designed for time-temperature control are modifications of the usual temperature controller in which the temperature setting is varied with time. This result is obtained by clock-driven cams designed to shift the value of the controlled temperature as desired during the cycle of operation. Obvious advantages result from uniform heating and cooling rates as well as uniform time at temperature in giving a product that is constantly uniform regardless of the operator, or the conditions under which the equipment is used.

Time-temperature controllers can operate electrical signal systems giving remote indications of the process. Air valves within the controller can be connected to pressure-operated plungers, valves, or levers, or the controller may function electrically.



In the Bristol process control instrument (left) for the rubber molding press shown below, clock-driven cams open and close small air valves which in turn control high-pressure valves, steam supply, interlocking mechanisms and signal lights



Additional functions can be incorporated in these controllers to completely mechanize such processes as bakelite molding, die casting or rubber presses. Not only can time and temperature be held the same for each operation, but the entire cycle of operation can be placed under complete automatic operation. In modern rubber molding presses, for example, the operator needs only to place the work in the press and start the cycle by closing a contact. Thereafter, the platen is raised and locked, pressure applied, temperature applied and controlled for the proper curing time during which tests may be made periodically; after the desired time has elapsed, the pressure is turned off, the press unlocked and the platen lowered, leaving the operator only the necessity of keeping the press supplied with work. Indicating lamps built into the press can be lighted to show the progress of the cycle, while lamps, counters or recorders can be operated.

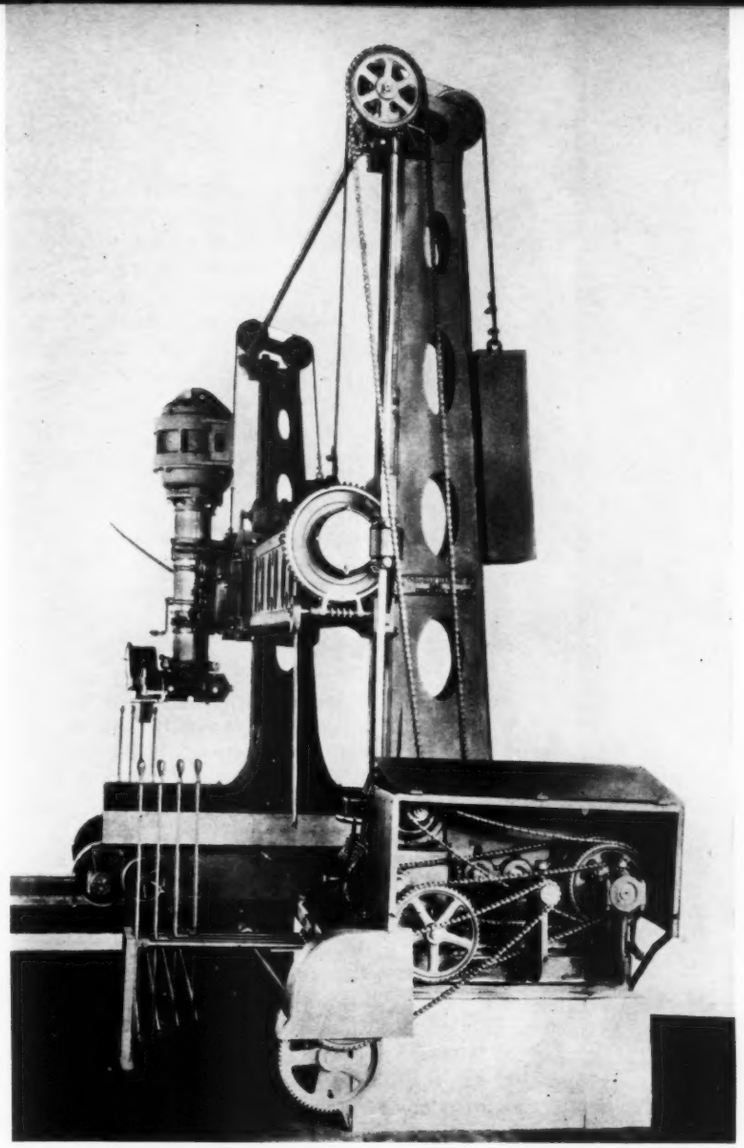


Fig. 10—Two-way coper for grinding marble, built by the Ty-Sa-Man Machine Company, showing the chain drives for operating the cross rail, feeds and table

Designing Chain Drives—III

Factors relating to position of drive, relative location of sprocket gear and pinion, slack adjusters, maximum number of teeth and speed ratio

ONE advantage peculiar to chain drives is that the oil films at the pin bearings will absorb much of the shock in such drives as for crushers, construction equipment and heavy machinery. For this reason, chains for such applications should be inclosed and provided with adequate lubricating means. Good lubrication under any conditions will greatly increase the chain life, even when the chain is overloaded and overspeeded.

Lubrication of a chain drive may range all the way from occasional dabs of oil on an open chain to flood lubrication in a closed drive. Indicative of the increased capacity that may be obtained through good lubrication, one chain manufacturer states that the power transmission capacities as listed in his tables may be increased as much as 10 to 25 per cent or more, when exceptionally good lubrication is provided. Another chain manufacturer has specified drip-feed lubrication for medium speed drives and for high speed he recommends flood lubrication with the chain running in oil in the bottom of an inclosing case. For speeds above 1,500 ft. per min., an oil-throwing disk or slinger arm should be used instead of running the chain in oil, as the oil will be churned too much if the chain runs through it at high speed. Slow speed is defined as less than about 500 ft. per min., high speed as greater than about 1,500 ft. per min., and medium speed between these two velocities.

Because chains wear out and wear rate increases rapidly with increased speed, it is evident that better lubrication must be provided for the higher speed drives. It is claimed that for any drive, good lubrication practically stops wear. The question of lubrication will be treated in detail in another article.

The most favorable position for a chain drive is with the center line of the sprockets horizontal or at an angle up to about 60 deg. With small sprockets or long drives the slack side should be the lower span to avoid the possibility of the loose upper strands making contact with the tight lower strand. If this cannot be avoided, the sprocket centers should be made adjustable or a slack adjuster should be provided. Vertical or nearly vertical drives should be avoided if it is convenient to do so.

With a vertical or nearly vertical drive, some form of adjustment is

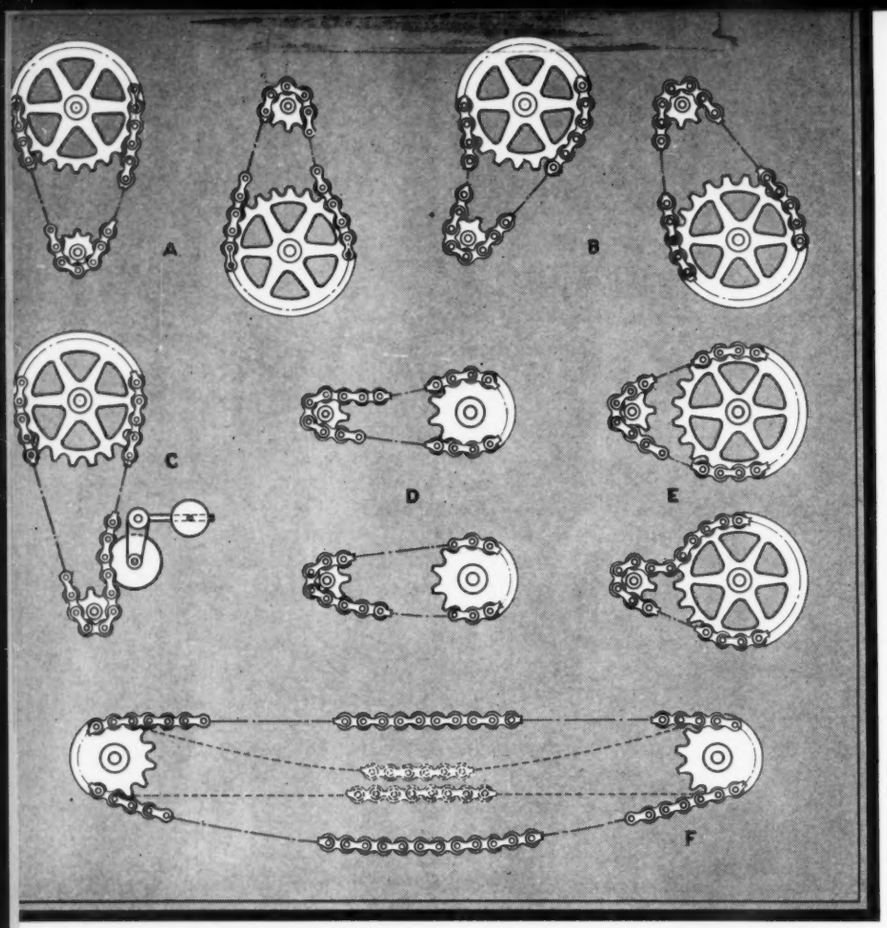


Fig. 11—(A) In vertical drives the larger sprocket should be below. (B) Slightly off vertical improves the drive. (C) Slack adjusters assure a snug fit. (D) For normal centers slack may be either upper or lower side, but for short drives (E) or long drives (F) preferably on lower side

essential for the proper operation of the drive. This will assure a snug fit of the chain, which is desirable. In such drives the lower sprocket should not be too small as that would result in the chain tending to hang away from the sprocket even with only a normal amount of slack.

On short horizontal drives it is often desirable to have the slack side run on the bottom. With the slack side on the top there may result a reverse curve in the chain, but in many instances with normal centers and reasonable size sprockets, the slack side may be either at the top or at the bottom.

Slack adjustment should be provided not only for vertical drives, but also for all drives with small wheel diameters and long centers. Some form of slack adjustment may have to be provided when the load characteristics are of a pulsating nature. On motor drives it is generally convenient to have the motor mounted on an adjustable base. Many types of both manual and automatic chain tension adjusters are available. In Fig. 13 are shown five types of chain tighteners as manufactured by the Link-Belt Company.

Chain-tension adjusters should be placed where the greatest amount of slack accumulates. The position of the take-up with respect to the driver and driven sprocket will affect the length of slack that the adjuster can take up. The most effective position is on the slack side of the chain and as close to the driving sprocket as may be feasible. It should be arranged so that when the adjustment is exhausted it will be possible to remove two pitches of chain and put the adjustment back to the position that it was in originally.

If there is inclined to be any roughness in the drive because of the characteristics of the prime mover or driven unit, a longer chain life can be obtained if adjustment is provided. Means for adjustment make it possible to maintain the initial operating tension, thereby limiting possible whipping action.

There is much difference of opinion as to the desirable initial slack to be allowed, and there would be many exceptions to any general rule. The safest generality seems to be that a chain should be installed snug but not taut, although in some drives subjected to impulsive loading a taut chain will decrease the tendency to whip.

For the average drive the chain should be replaced after elongating 3 to 4 per cent. With small sprockets replacement of roller chains is usually made necessary by the case hardening of the pins and bushings wearing through, but this rarely occurs when the sprockets have a reasonable number of teeth.

There is no definite limit to the maximum number of teeth that can be used. In drives with exceptionally large sprockets, the number of teeth in the large wheel will determine the maximum permissible chain wear; the greater the number of teeth in the sprocket the less will be the allowable per cent elongation.

There is a direct relation between the permissible number of sprocket teeth in the gear and the allowable elongation of the chain. The pitch of the sprocket teeth remains constant, while with uniform wear the chain pitch increases in the same ratio as the total length of the chain. For any given pitch and elongation, the greater the number of sprocket teeth the nearer the chain will ride to the tops of the teeth.

With 60 to 65 teeth, a chain elongation of 3 per cent

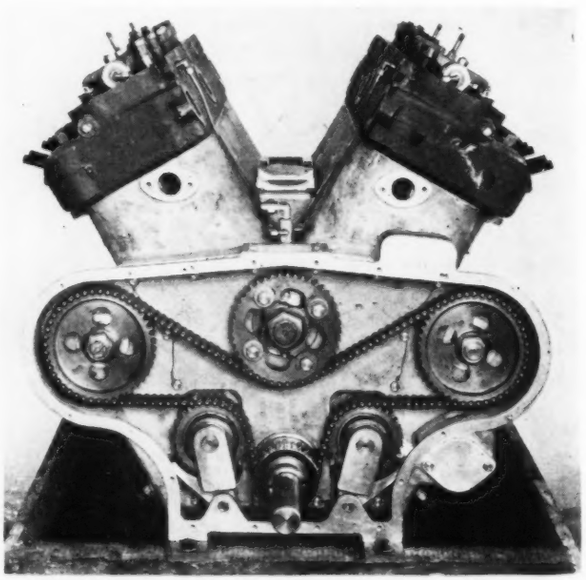


Fig. 12—Roller chain double-camshaft drive on 200-hp. Hill V-8 diesel running at 1,700 r.p.m.

will cause the rollers to contact the clearance curve, for the reason as explained. With 90 to 95 teeth the chain usually must be discarded after it is about 2 per cent longer than its original length, although the discarded chain can then be used further on 60 to 65-tooth wheels, on which it will mesh properly. With sprockets of 180 to 195 teeth, 1 per cent is about the maximum allowable elongation. On the other hand, even a badly worn roller chain never tops the teeth of sprockets of 30 to 40 teeth or less. Hence as a generality, beyond a certain point an increased number of teeth decreases the useful life of the chain because it limits the amount of permissible elongation.

All other conditions being the same, equal chain life will be obtained with sprockets of 60 to 65 teeth and sprockets of 180 to 195 teeth if the power transmission capacity of the chain for the latter is about three times as great as that for the former. Thus, a single strand roller chain on a 60-tooth sprocket and a triple strand chain of the same pitch on a 180-tooth sprocket wheel will both have about the same life, all other condition remaining the same. The above applies to both roller and silent chain.

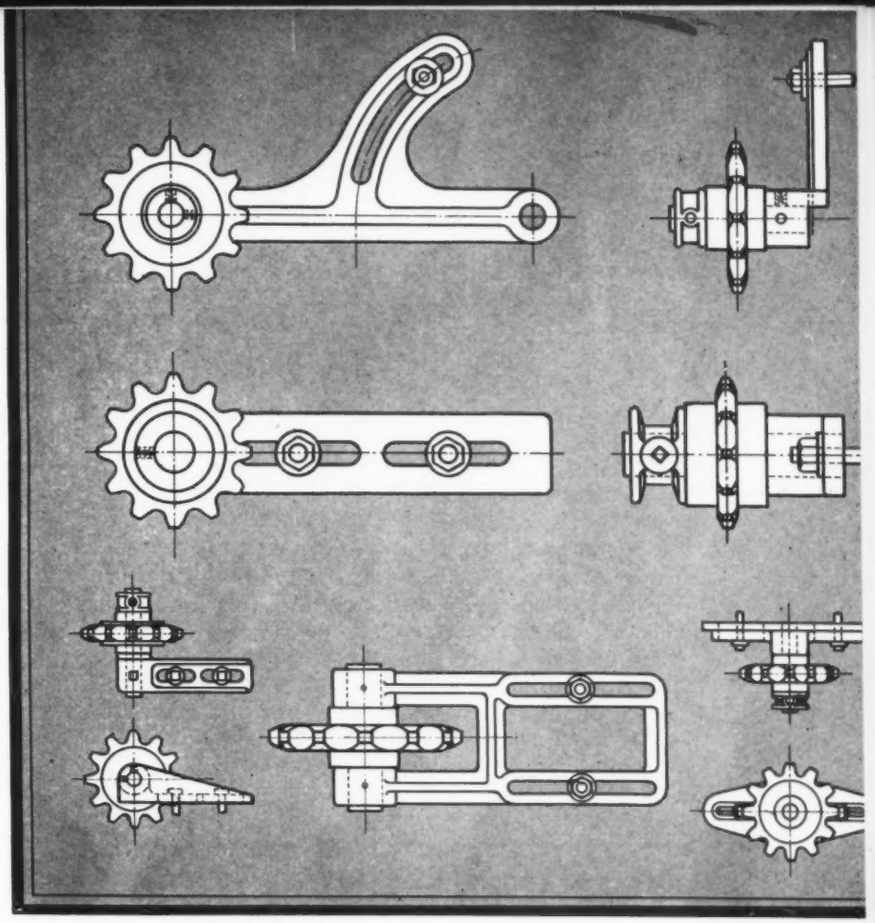


Fig. 13—Five types of chain tighteners as manufactured by the Link-Belt Company

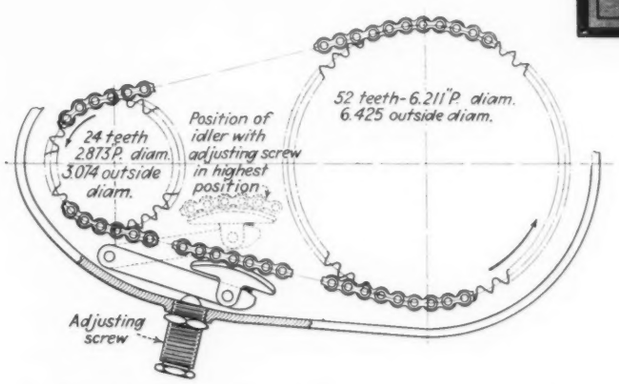


Fig. 14—Short center drive on Indian motorcycle, showing operation of chain tension adjuster, a patented design of Baldwin-Duckworth Corporation

Most chain manufacturers recommend a maximum speed ratio of 7 or 8 to 1, although successful installations with a speed ratio as high as 10 to 1 are in use. One of the limiting factors in the speed ratio is the included angle between the chain. This will be determined by the center distance between the sprockets and their diameters. Another limiting factor is the permissible number of teeth in the larger sprocket.

In Fig. 15 is shown why the chain angle limits the speed ratio. As the chain angle increases the number of teeth in effective mesh with the chain decreases. Generally, 60 deg. is considered to be the maximum permissible angle between the tight and loose sides of the chain; one manufacturer specifies 45 deg. as the maximum. A 60-deg. chain angle corresponds to 120 deg. of chain wrap around the pinion sprocket. A generous wrap, especially on the driver, distributes the load better among the sprocket teeth and also makes for better meshing of the chain on the sprocket. There should be a minimum of 5 or 6 pitches in mesh with the sprocket, more would be better. For idlers, three is adequate on many applications.

Most chain manufacturers recommend a normal center distance equal to 40 pitches. This is considered to be the ideal but permits of wide variations. The center distance should be such that there will be an even number of pitches in the chain. An odd number of pitches will require an "offset" link. It is for this reason that slack adjusters should be arranged so as to allow two pitches to be taken out of the chain when all the adjustment has been taken up.

The minimum center distance is that merely sufficient to assure clearance between the driver and driven sprockets. One conventional rule is that the minimum distance between sprocket centers should not be less than the diameter of the larger sprocket plus one-half the diameter of the smaller sprocket. The only significance of this is that such a minimum center distance will assure clearance between the sprocket teeth.

When the centers are close, a check should be made to make certain that there will be no interference between the teeth.

Properly designed chain drives will operate with little or no noise. When a drive is noisy it is often found that it is caused by the mountings greatly amplifying the slight noises made by the chain. The same precautions for noise reduction should be taken in the design of chain drives as in other types of drives.

Minimum noise in chain drives is obtained when a fine pitch chain is used, lubrication is good and the

bearing mountings are rigid. One source of noise is the use of pinion sprockets that are too small.

With reference to the types of sprockets, these are obtainable in a wide range of stock sizes and patterns in both cast iron and steel. Chain manufacturers also make them to any desired special design. Steel pinion sprockets are often case hardened to increase the wear resistance of the teeth. Plate type roller chain sprockets with separable hub are obtainable with a shear pin between the hub and plate. An excessive overload will shear the pin, which can be replaced readily.

Sprockets for silent chains usually have a center guide. Side guides, on either chain or sprocket, are also obtainable, but the center guide is preferred. For wide sprockets several "center guides" are used.

Chains of special materials are available for meeting unusual conditions such as high temperature and corrosive fumes or acids. Bronze roller chains are resistant to many media. But it should be borne in mind that bronze chains are not equally resistant to all corroding agents, nor equally resistant to the same agent under all conditions. The chain manufacturer should be consulted for his recommendations as to the material most suitable for a given condition.

Stainless steel, 18-8, roller chains are resistant against most of the media for which bronze chains are recommended and also many media for which bronze is not recommended. But as in the case of bronze chains, stainless steel chains are not equally resistant to all corroding agents, nor equally resistant to the same agent under all conditions.

State laws may require the use of stainless steel chains even where bronze may be suitable for corrosion resistance. While not generally adopted in all states, laws are now being enforced in several states barring the use of bronze when it comes in direct contact with food, unless the bronze is tinned.

For many high-temperature applications stainless steel chains are excellent. Roller chains for use at temperature up to 1,600 deg. F. must be made of a material that will be strong and tough and resistant to scaling at that temperature. Stainless steel meets these requirements, in addition to which it is resistant to many corrosive media at elevated temperatures.

Scaling conditions are dependent upon the nature of the atmosphere to which the metal is exposed and the actual temperature at which a stainless steel roller chain may be used also depends on the atmosphere.

Undoubtedly the most important factor in chain drives is lubrication. The fourth and concluding article of this series, which will appear in the August number, will be on the subject of chain drive lubrication. Relative chain life with different types of lubrication, recommended provisions for lubrication and a discussion of the different lubricating means will be included.

• This series of articles which began in May is based on interviews and correspondence with the chief engineers of the following manufacturers:

The Boston Gear Works — **Link-Belt Company**

Chain Belt Company — **Morse Chain Company**

The Baldwin-Duckworth Chain Corporation

Diamond Chain and Manufacturing Company

Ramsey Chain Company, Inc.

The Whitney Manufacturing Company

• Their assistance in furnishing the data and information and in contributing directly to the writing of the articles, is gratefully acknowledged.

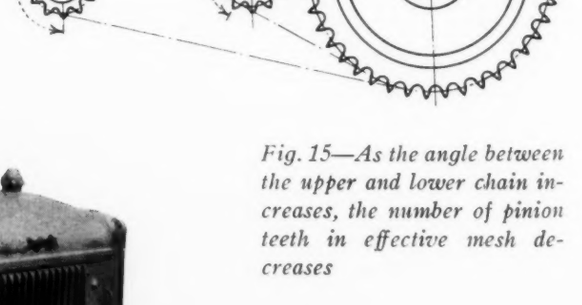


Fig. 15—As the angle between the upper and lower chain increases, the number of pinion teeth in effective mesh decreases

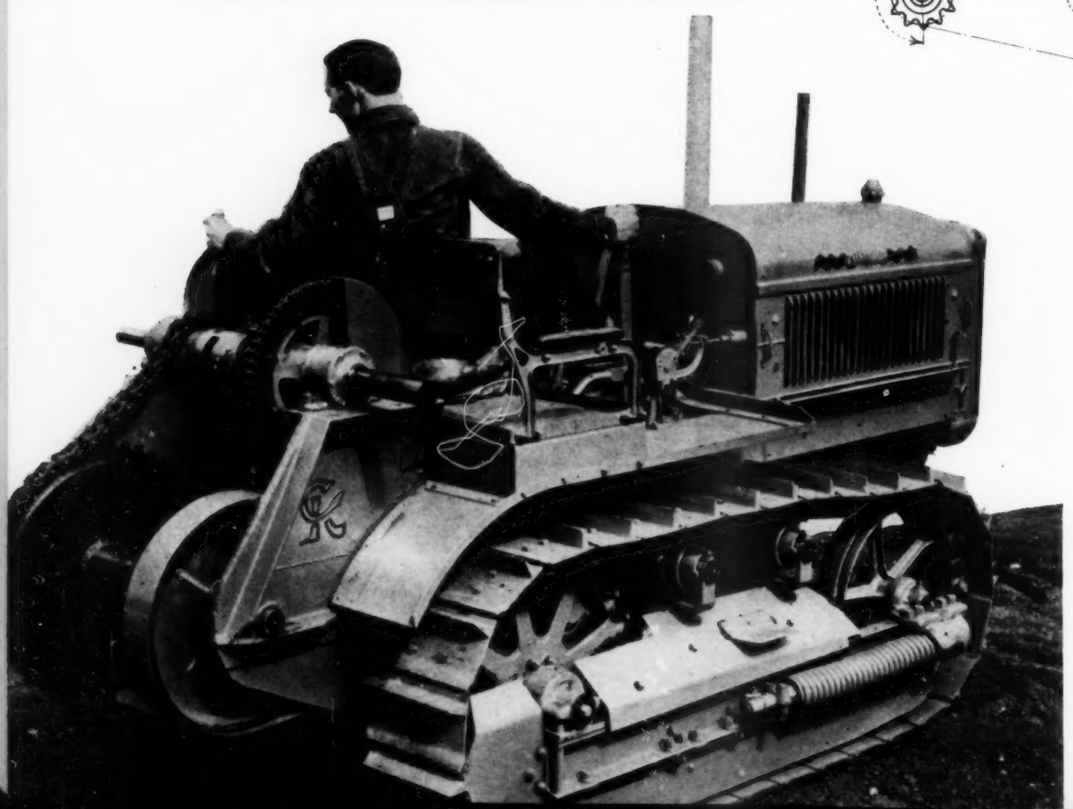
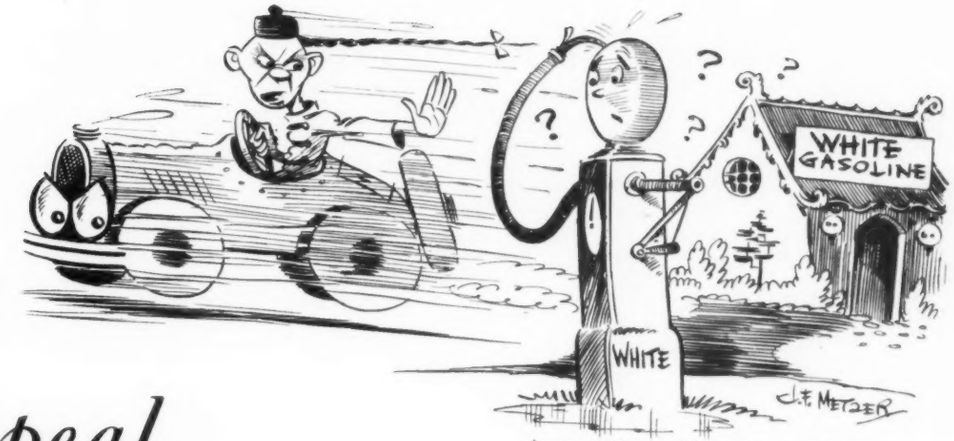


Fig. 16—Chain driven towing winch built by All Steel Products Company, mounted on a Caterpillar tractor

Product Appeal Through Correct Color



In China, white means mourning; hence no sales appeal

HOWARD KETCHAM
Color Engineer

First of a series by Howard Ketcham, editor of the *Automobile Color Index* and for eight years director of the Duco Color Advisory Service of E. I. du Pont de Nemours Company, Inc. Mr. Ketcham has now established New York headquarters, and while still retained by the Du Pont Company, other major fields of industry are benefiting by his scientific color counsel. This article, like those which are to follow, gives convincing reasons why color plays a strong hand in attracting or deflecting business.

PRIMITIVE vegetation was responsible for the first use of color in a promotional sense. Plants depend on insects for pollination, and those that attracted attention most successfully were better fertilized. Later, the color sense became inherent in insects, birds, fish and animals. From this it can be seen that the first use of color was not aesthetic but practical, and played a large part in the preservation of the species.

Nature's use of color has imparted an important fundamental to man. Man has found that certain colors sell becuse they are the magic key to the consumer's fancy, while certain other colors do not sell because they violate the exact science of color. A big electrical appliance company recently lost a $250,000 South American order for flat irons because some executive thought black handles would do. But a competitor, knowing that the South American market had to have red handles, and of a particular kind of red, got the order.

A certain red pulls more than 50 per cent of the total sales in the ten cent toothbrush market. But red in the twenty-five cent toothbrush has practically no appeal, while amber has.

Why has the color of a product so much to do with its sales? Psychologists have many answers. The essential fact is that people do react in different ways to different colors. And the subconscious reactions to color can be harnessed and directed to a desired objective.

Color sells eggs— It has been found that white eggs sell successfully in blue-lined containers because blue imparts contrast to white, thereby giving the eggs greater eye-appeal. Similarly, brown eggs appear best in white-lined containers.

Color "heats" rooms— The women's cafeteria in a big factory was decorated in a light greenish-blue. Complaints were made about the room being cold. The plant engineer knew that the temperature, thermostatically controlled, was the same as elsewhere in the building. Bright orange covers were made for the backs of the chairs and the baseboards were painted the same color. Immediately the complaints ceased.

Effective box office returns are achieved through color— Stage settings and colored motion pictures depend entirely upon the skill with which the eye is stimulated in order to produce desired effects. In the case of the stage setting, success is frequently achieved by arousing the eye with one color in the setting, so that when the performers enter dressed in a contrasting color, the eye suddenly regains stability and satisfaction. Even when neutralized colors are employed, it is of greatest importance to attain such stability as is accomplished with pure colors.

Color pulls inquiries— It has been found that there is an amazing difference in the attention and action value of various paper color combinations in direct-mail results. A manufacturer desiring to market a new electrical appliance, circularized a selected list of 11,000 prospects. The mailing was divided into eleven groups of color combinations. One thousand of each group received the same copy, with the same letterhead design, but each group received the message on a different

colored paper with a mailing envelope of a contrasting color.

Here is a tabulation of the percentage of responses that different colors pulled for this manufacturer:

Percentage Responding	Color of Letter Paper	Color of Envelope
48	Pink	Blue
34	Canary	Blue
28	Green	Blue
26	Pink	White
26	Corn	Blue
21	Canary	White
18	White	White
16	Green	White
14	Corn	White
12	White	Blue
9	White	White

While the effectiveness of blue would likely be dissipated if advertising mail were too liberally sprinkled with blue envelopes, the power of distinctive color has been conclusively demonstrated by this and other tests.

Color is employed to relate quality to the price of agricultural products— The Bureau of Agricultural Economics, United States Department of Agriculture, measures the color of hay, cotton, grains, fruits and vegetables in terms which adequately approximate the psychological color attributes of these commodities. These measurements make it possible to determine satisfactorily the price categories into which various classes of agricultural products can be classified.

Color serves ideally as a low-cost means to evade the appearance of product standardization. Colors are used today to express quality and to fix trade-mark associations on consumers' memories. Used in this connection, colors should be visible, bright, appropriately significant of products and not too customary.

Because red is first in attention value and because an advertisement must be seen before a prospective buyer can read it, 75 per cent of all color advertisers in a leading publication employ red as the principal color.

A large oil company with filling stations in China, painted them white—just to be different. But in China, white happens to be the color of mourning. The experiment was an expensive one.

Through the introduction of timely color combinations, fountain pens have acquired style and smartness—become subject to the vogue—with the result that sales have advanced more than 50 per cent because of this innovation. Formerly, black and red were the only choice; today, those colors represent less than 10 per cent of total sales.

Some research agencies feel that they have done their job when they determine for a client just what the consumer appears to prefer on various items. For example, they may determine that people with incomes of $2,500 a year or less, prefer blue on a household utility costing $10; that those with incomes ranging from $2,500 to $5,000 prefer green and that those with incomes in excess of $10,000 prefer grey. They may feel that this is a sufficient analysis of color appeal. But there happen to be many blue hues. Thus, there are greenish blues and purplish blues. Furthermore, each hue has high, middle and low values and weak, moderate and strong chroma variations.

Moreover, color reactions are not general. They are specific to a certain hue, value and chroma of a certain color. If a market analysis for color appeal is to have any worth whatsoever, it must determine the exact hue, value and chroma desired.

By knowing the colors to which the public is most susceptible, smaller inventories can be maintained, thereby confining patterns and designs to the most salable ones. Through constant analysis of the colors which the public has favored and is favoring, it is possible to keep successfully alert to style trends. In this way, production can be efficiently geared with what the public is buying and with what it will buy next month or next year.

Knowing the accepted significations that are accorded to certain colors in connection with important events, sensations, ideas and emotions, the correct colors have positive sales value in stimulating product appeal. Revolutionary changes in color treatment and merchandising methods have been induced through the acceptance of industrial color guidance. The automobile a few years ago was presented to the market finished in as many as eight different colors. In a number of instances, window reveals, mouldings, belt, stripe, wheels, fenders, upper and lower body areas, had each a separate and distinct color. Today cars are finished in one all-over color. Many have no stripe. Manufacturers study geographical color preference, in order that the cars sent to a given area will sell quickest through appeal to local color preference.

Today it is possible to transmit color specifications with telegraphic speed through the use of a standardized mixture data. This saves the time and expense entailed in old-time methods of mailing sample cards. It makes it possible to have accurate color representations of color ideas originating in Paris or Hollywood transmitted by wire to any part of the world, as quickly as they are available.

It is not enough to know how to select and combine colors to win markets today. Merchandise must be presented to the public with proper sales psychology.

With competition along lines of price, quality and workmanship, color affords the most logical attribute for product excellence. There is no limit to the variety of inventions which the imagination is capable of producing. While there is no such thing as a new color, colors can be combined in endless ensembles to fit every practical purpose. Without color, there could be no design. There is nothing in this world without its distinctive color.

Red is first in attention value

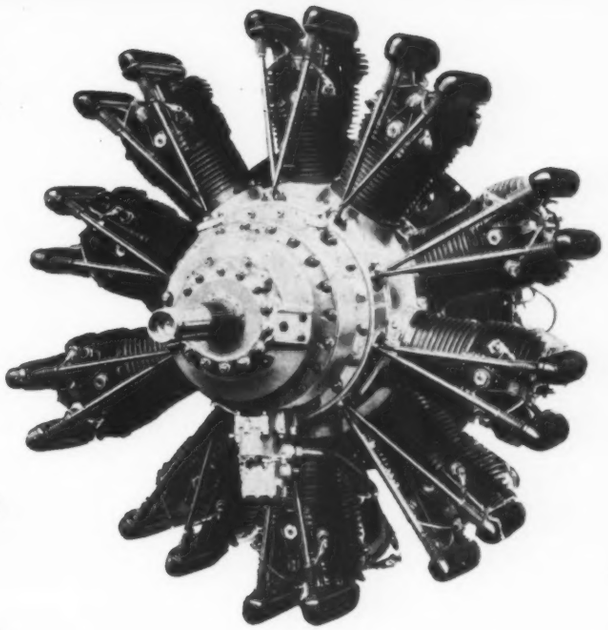


Fig. 1—Accurately cut reduction gears make possible higher speeds in aviation engines

Design of Gears for Minimum Noise

WILLIS G. MEYERS
Detroit Motor & Engineering Company

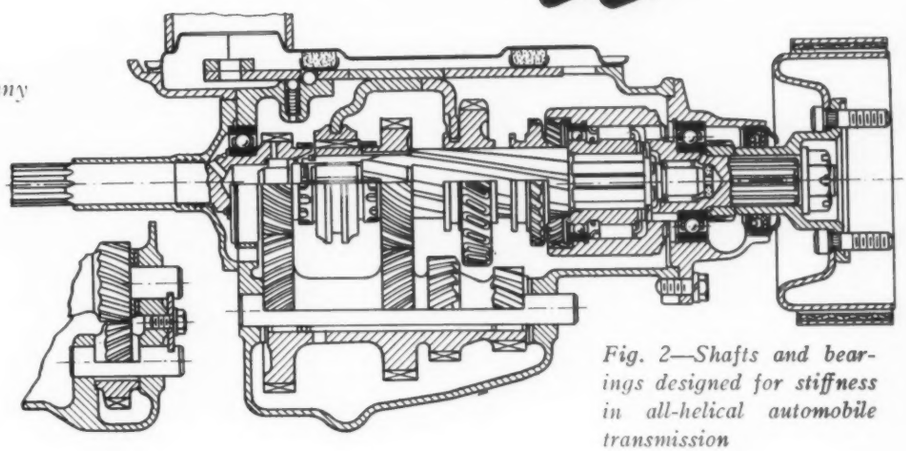


Fig. 2—Shafts and bearings designed for stiffness in all-helical automobile transmission

THE meshing of improperly made gears results in vibration. Not only are the physical characteristics of metallic gears such that the transformation of the vibrations into sound is facilitated, but this sound may be amplified by the housing or gear box which incloses the drive, often reaching a volume and pitch that is objectionable. Herein are the elements of an unsatisfactory gear assembly. The ear is capable of distinguishing sounds arising from 32 to 12,000 vibrations per second and frequencies within this range usually occur in gear practice.

In many instances vibration dampeners are provided so that the resulting sound will be of lower pitch, as such sounds are considered less unpleasant. Some effort is also being made to use sets of gears that will produce sounds which are harmonious rather than discordant. A number of European automobile manufacturers are using transmissions with all gears on the countershaft having the same number of teeth. The pitches of the teeth are made different to give the variation in ratios, but the tone produced by all the gears is the same because the number of contacts are the same in all gears.

There are three characteristic types of noises in gear drives: (1) a steady growl or hum caused by inaccurate tooth spacing or inaccurate tooth profiles; (2) a pulsating growl emanating in regular cycles, which is usually a sound produced by gear eccentricity, and (3) a high pitched whine resulting from rough tooth surfaces. These noises can be minimized by improvements in the workmanship and installation of the gears. Other sounds and combinations of sounds built up by amplification are more difficult to analyze.

In a pair of straight spur gears, even though manufacturing perfection were possible, wear would inevitably destroy the relationship of the meshing teeth. The problem is thus one of designing and manufacturing gears that will be less susceptible to variations in tooth profile, eccentricity and spacing; in developing manufacturing methods capable of more accurate control of gear dimensions; and in developing gear materials and mountings which will have a damping rather than an amplifying effect on vibrations.

Since present production methods are such that commercial spur gears cannot be quiet enough, some other form of gear can be chosen if silent operation is required. The helical gear is usually the cheapest, most efficient, and most used type, while the double helical or herringbone gear is being used more than previously. If the face width, pitch, and helix angle are properly coordinated and the gears are correctly mounted, they will run quieter than spur gears. Having a continuous tooth contact at the point of tangency of the pitch circles, there is less chance of vibration in helical gears than in spur gears because of errors in tooth profile.

There are four possible types of inaccuracies introduced during the manufacture of helical gears, these being errors of the profile form, the spiral angle, eccentricity, and tooth spacing. Improvements have been made in recent years in the production of accurate gears, and tolerances being maintained now were unheard of five years ago. For automobile transmission gears, modern practice requires that the pitch circle be concentric within 0.001 in. and that tooth spacing be held within 0.0005 to 0.001 in. Modern gear grinding machines

using master gears are capable of reproducing the accuracy of the master gear, which is plus or minus 0.0001 in., but in high production, when time is at a premium, plus or minus 0.0002 in. is generally considered satisfactory. The helix of helical gears is generally held within 0.0001 in. per inch of tooth face. Several years ago, gears having errors of plus or minus 0.002 in. in tooth form were considered good, and hobbed gears with errors 0.003 in. between adjacent teeth were considered as good as could be produced in quantities.

Gear Finishing Processes

Grinding and lapping are the two processes for accurately finishing gears after heat-treatment. In the grinding method, which is more expensive, the gears are cut, heat-treated, and then ground. Distortion that occurred during heat-treatment can be corrected in the lapping. The selection of either method depends upon the individual requirements of the gear.

The success of lapped gears depends upon the amount of distortion or "fire change" which occurs during heat-treatment, and upon the accuracy with which the gears are cut. The gears must be accurate in contour, spacing, concentricity, and helix angle within 0.001 in. This is not difficult for small gears if proper precautions are taken, but in large gears such as those used in electric locomotives and in aviation engine reduction gears where speeds are high and loads are great, the lapping process is not as satisfactory as the grinding method. The tooth profile in small gears can be held within 0.0005 in. when cut with hobs or shaper cutters so that the total change is within the capacity of the lap. Some gear makers predetermine the amount of "fire change" and make allowances in the hob.

In the heat-treatment of the gear, rapid heating, slow cooling and low quenching temperatures are necessary. The latter is obtained by the use of alloy steels which have a low critical point, as those containing nickel and molybdenum. Slow cooling at quenching can be obtained by the use of an oil bath.

Gears should be forged at controlled temperatures in dies designed so that the full pressure of the forging machine ram is used to compress the forging itself and is not wasted in trying to compress a cold flash. The result is a dense forging which dissipates heat at a uniform degree during the normalizing and hardening operations.

Grinding is the most satisfactory process for finishing gears and should be specified in instances where the in-

FIG. 3

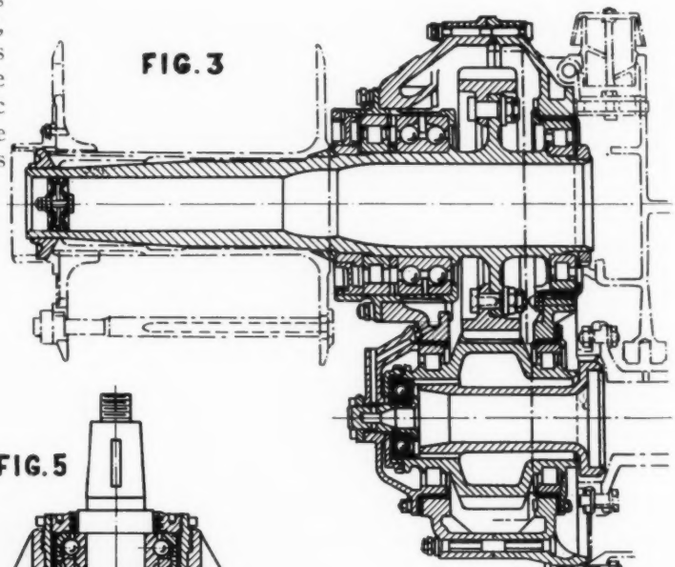


FIG. 4

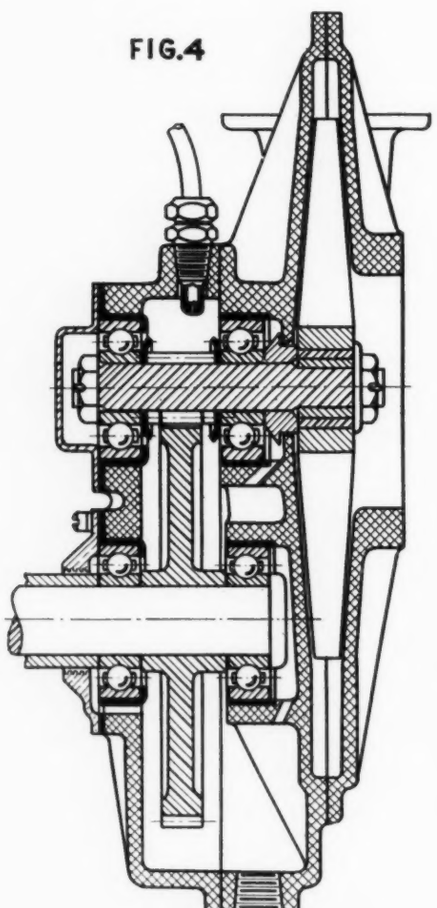


FIG. 5

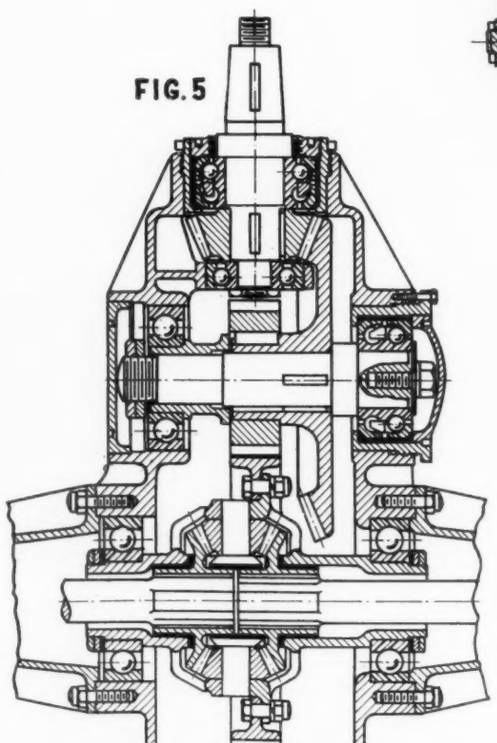


Fig. 3—On Rolls Royce aviation engine reduction gear, pinion and bull gear are not subjected to deflection or torsional vibrations of crankshaft

Fig. 4—Driven gear in racing automobile supercharger rotates 40,000 r.p.m. Tooth accuracy and rigidity of gears, shafts and bearings contribute to efficiency

Fig. 5—Vibrations are reduced by ball-bearing straddle mounted gears in double reduction rear axle of automotive truck

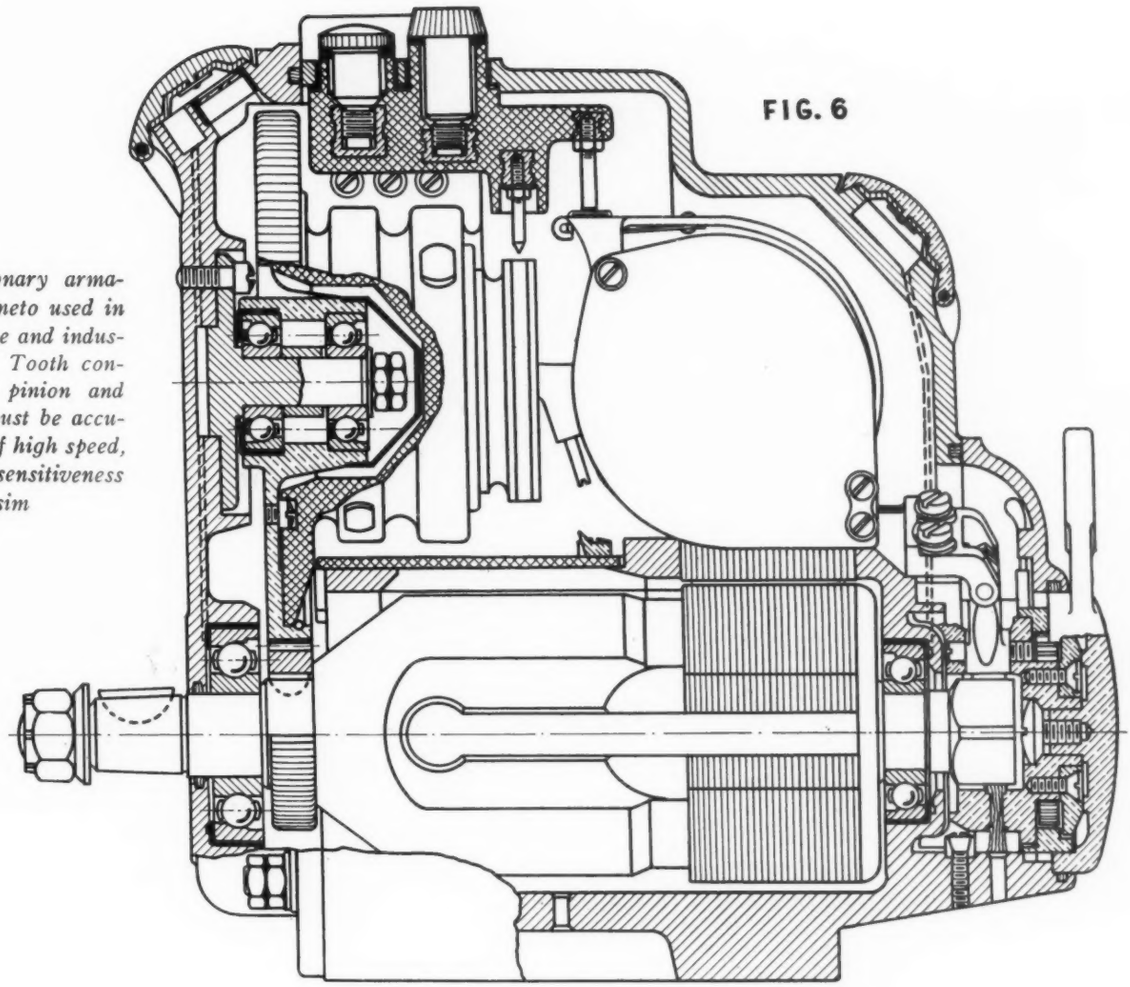


Fig. 6—Stationary armature type magneto used in aircraft, marine and industrial engines. Tooth contour of steel pinion and bronze gear must be accurate, because of high speed, delicacy and sensitiveness of the mechansim

crease in cost is permissible. When the grinding process is used it is not necessary to cut teeth to extreme accuracy and "fire change" is not important. The only requirement is that sufficient stock be allowed to permit proper accuracy during the grinding operation. The excess stock on the tooth thickness is generally from 0.008 to 0.016 in., tolerances on other dimensions being proportional.

Soft Steel, Bronze and Molded Gears

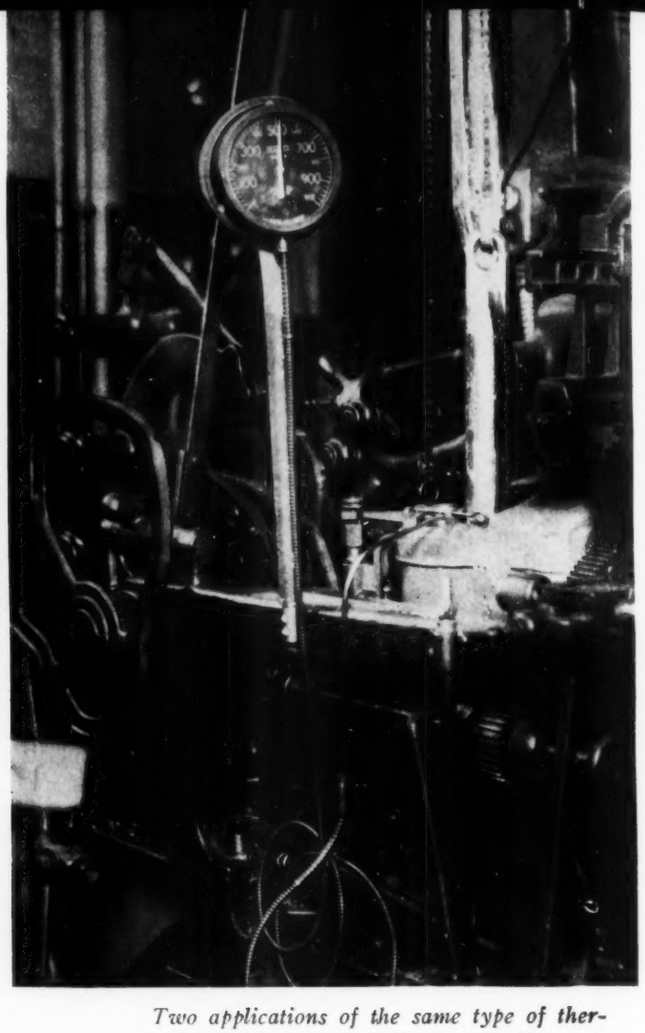
In some applications where the use of hardened steel gears is not necessary, a combination of steel and bronze may be used. The steel gear should be rough hobbed, heat-treated for toughness to a hardness which will allow machining, and then finish hobbed as a final operation. SAE 1040 or a similar alloy steel, heat-treated to a hardness of 275 to 300 Brinell, is an excellent material when the mating gear is made of one of the high strength bronzes now available. Accuracy can be obtained on both gears without grinding or lapping, so that the drive is as quiet as it is possible to make a pair of gears. Such a gear train is capable of withstanding high speeds and tooth loads, and wears well.

The use of non-metallic gears made of laminated plastics such as Micarta, Synthane, Textolite, Celeron and Formica are quiet in operation and necessary in some installations, such as in timing drives in automobile engines. The non-metallc gear is satisfactory for high speeds and relatively light loads.

Accuracy of manufacture, however, is not the final solution of the noise problem in gear drives, as it has been found in numerous instances that gears properly designed and manufactured to the finest tolerances possible have proved disappointing when operating in the machines of which they are a part. Automobile manufacturers have found that the gear transmissions which pass sound tests will be quiet in one car and noisy in another car having only a different style of body. The reason for this anomaly is that certain sound frequencies below the audible range of the human ear are produced in many truly silent transmissions.

The use of resiliently mounted gear boxes has proved a great help in some instances by eliminating the transmission of vibrations to larger members of the machine. Insulation of shafts by spring or rubber drives has also proved satisfactory. It has been suggested that gear boxes be insulated, but because of the great amount of insulating material required, this might be impracticable.

The mounting of the gears is also important in the design of quiet gearing. Precision manufacturing of the gear will be superfluous if the flanges and webs, shafts, and bearings are subject to appreciable deflection.



Two applications of the same type of thermometer. In one the instrument problem was left to the machine user

Temperature and Electrical Measuring Instruments

EACH of the five types of temperature measuring instruments has unique characteristics making it specially suitable for certain fields of application. Whether an expansion, vapor pressure, electrical resistance, or thermocouple type of thermometer or a radiation pyrometer is to be used will depend on the temperature range to be covered, maximum and minimum temperatures, sensitivity required, and the function to be performed by the instrument. The instrument may serve to indicate the existing temperature, or to record it, or to control the operation of devices such as power-operated valves. In many applications the proper selection of type and design of instruments requires the assistance of technical experts of instrument manufacturers. But on the other hand there can be no intelligent selection until the designer of the product on which the instrument is to be used has determined the requirements to be met. The designer must determine service conditions and establish the factors that might affect the operation of the instrument selected.

Perhaps the first consideration in the selection of a temperature measuring instrument is the range to be covered. Temperatures as low as —300 deg. F. and as high as approximately 3,000 deg. F. can be measured. Even higher temperatures can be measured with radiation or optical pyrometers. But no one type of instrument is suitable for all applications over this complete range.

Mercury in glass thermometers are available for indicating temperatures up to about 600 deg. but they are not generally used for temperatures much above 300 deg. F., and are accurate within 2 per cent error. Bimetal thermometers are made for temperatures as high as 1,100 deg. F., but their accuracy, particularly in the higher temperature ranges, is not equal to that of the mercury in glass thermometer.

Where greater accuracy is required or higher temperatures are involved, thermometers of the vapor-pressure or the electrical type must be used. A pressure-type thermometer is essentially a pressure gage at one end of a closed system, at the other end of which is a bulb containing volatile liquid. Or the whole system may be liquid filled or gas filled.

In the vapor-pressure thermometer, changes in bulb temperature cause corresponding changes in the pres-

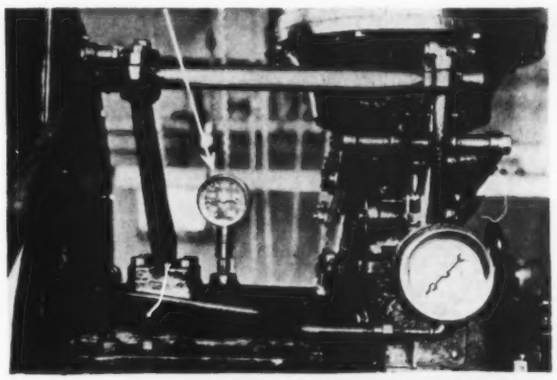
sure of the liquid vapor throughout the whole system. The temperature-calibrated pressure gage registers the temperature corresponding to the vapor pressure transmitted by the capillary tube which connects the gage to the bulb. The instrument has a relatively high rate of response, is accurate to about 2 per cent and is little affected by variations in the temperature of the case and tubing. The scale of the instrument is not uniform, scale divisions being spread further apart in the operating range. The upper limit of the temperature range is 350 to 700 deg. F., depending on the volatile liquid used.

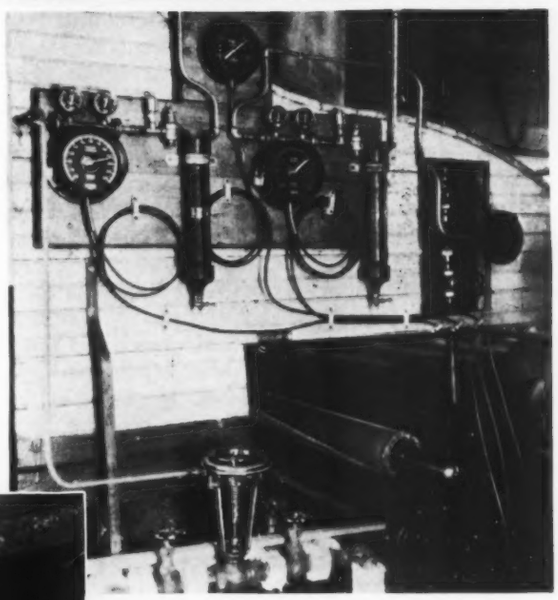
For temperatures up to about 1,000 deg. F., either gas-filled or mercury-filled pressure-type thermometers can be used. With inert gas, the pressures are nearly proportional to the absolute temperatures. To get large differences in pressure for a given change in temperature, the gas is put into the system under a relatively high pressure. With only the gas in the bulb being subjected to the temperature changes, it is necessary that this volume represent a large proportion of the total volume in order to reduce the error caused by temperature changes in the remainder of the system. Because of this relatively large volume of gas, the response of the instrument is slow.

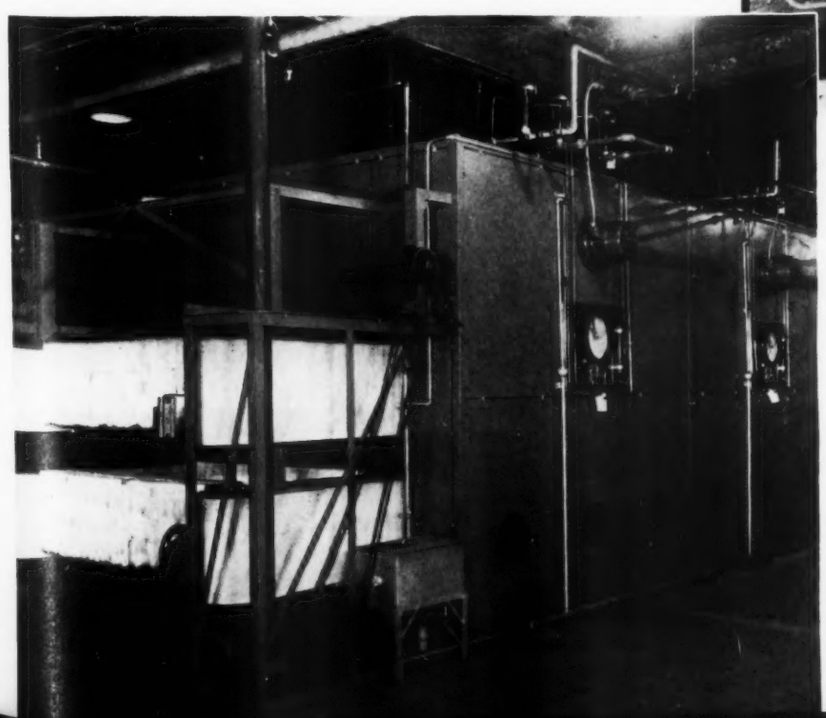
Liquid-filled systems operate on the expansion principle, the changes in volume operating an expansion chamber which actuates the temperature indicator. For temperatures up to about 350 deg. F. liquids other than mercury can be used but mercury must be used for higher temperatures up to 1,000 deg. F. All parts of the pressure system that come in contact with mercury must be made of steel to resist attack. In most designs, to compensate for changes in ambient temperature a bimetal compensation link is used. Also, the capillary tubing must be subjected to the same temperature as the case. As compared with vapor or gas-filled thermometers, the bulb is small. The liquid-filled instruments have good response, indications are accurate to about 2 per cent and the scales have uniform divisions.

Electrical resistance thermometers can be used for measurements in the range from —300 deg. F. up to about 1,000 deg. F. The upper temperature is limited by the ability of the material of the resistance wire to withstand the high temperature. Resistance thermometers are generally used in the low temperature ranges, up to about 300 deg. F., when the temperature must be determined with a high degree of accuracy.

In the electrical resistance thermometer changes in the electrical resistance of small coils of wire, caused by changes in temperature, are used to indicate the temperature. The resistance coils are inclosed in bulbs and the coils are individually adjusted to the desired temperature-resistance curve. These bulbs can be







(Above) Foxboro thermometer, indicated by arrow at top, for measuring bearing temperature. (Below) A group of non-recording temperature controllers for a textile slasher

(Left) Foxboro temperature and humidity controls built into a Proctor & Schwartz dryer assure uniformity of the product

calibrated to $\frac{1}{4}$ deg. F., if such accuracy is necessary. The response of the instrument is rapid because of the small mass of the bulb. Indicating instruments can be placed at any distance from the bulb, and a single instrument can be used to measure temperatures at a number of points by bringing the wires from each point to a switch near the indicating instrument.

For temperatures above 300 deg. F. the thermocouple type of pyrometer is generally used. This type consists of a deflection millivoltmeter or a potentiometer connected to a thermocouple—a pair of wires of different metals or alloys joined at the point where the temperature is to be measured.

As in resistance pyrometers, the maximum temperature is limited only by the ability of the materials to withstand heat. About 3,000 deg. F. is the upper limit. Overall accuracy depends on the characteristics of the electrical instruments and the thermo-electrical properties of the thermocouple. Electrical instruments, compensated for variations in instrument temperature, can be had with an error of only 0.1 per cent. Commercial tolerances in the matching of thermocouples permit variations of approximately 5 deg. F. from standard values in the higher temperature ranges, if this degree of accuracy is necessary.

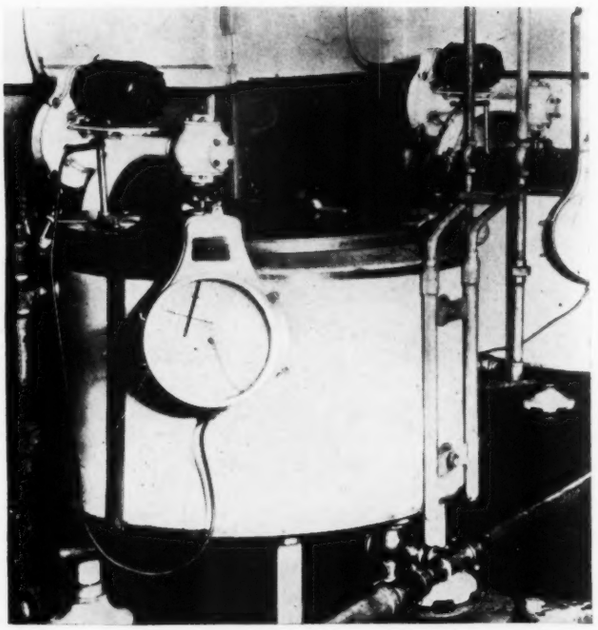
The choice between a millivoltmeter type of pyrometer and the potentiometer type is largely a matter of the accuracy required. Millivoltmeter type instruments are generally less complicated and require less attention. Potentiometer type instruments are capable of greater accuracy and are less affected by changes in the resistance of the thermocouple circuit than are millivoltmeters. Where accuracy of measurement is of primary importance, the potentiometer is preferred.

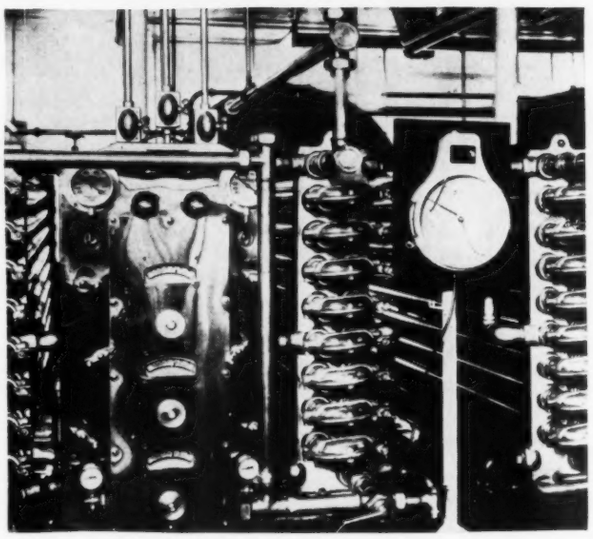
With the exception of the mercury-in-glass thermometers and the optical pyrometers, temperature measuring instruments can be equipped for recording the temperature, controlling the operations of valves, switches and similar devices, or doing both. Even the mercury thermometer is used to a limited extent for controlling electrically operated devices. Contacts are sealed in the stem at the point corresponding to the desired temperature. But the low current carrying capacity of the thread of mercury requires the use of sensitive relays.

Bimetal thermometers can be arranged to close electrical contacts directly. The energy needed to seat the contact firmly may result in some loss in sensitivity and accuracy, but in many applications this is of no importance. Bimetals are also used to tilt sealed-in-glass mercury switches. These operate relays that in turn control a motor or operate a valve or similar device.

All the pressure and electrical-type thermometers described here can be used for control purposes. In one design, a brush contacting a commutator mounted on the shaft of the indicating instruments controls the electric circuit. This may operate a sensitive relay or a "midget" motor, which in turn operates the switch for a motorized controlling mechanism, electric heating unit or other device.

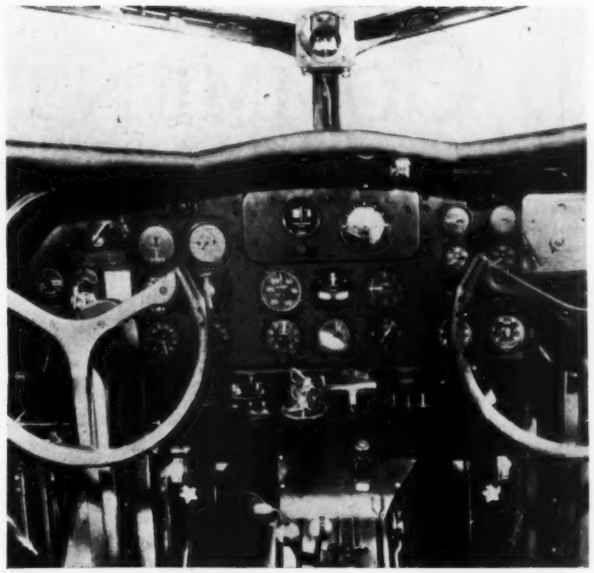
Another type of control system operates by compressed air. In the air-operated system, a constant pressure supply, usually at 25 lb. per sq.in., forces air through a small orifice into an air line leading to a bellows or diaphragm. In the air line is another orifice, somewhat larger than the first one, that is opened and closed by a vane in the temperature instrument. With this larger orifice uncovered, the pressure within the air line drops to a low value. As this control orifice is closed, the pressure in the air line rises, causing the diaphragm or bellows to expand. This movement then operates the controls.

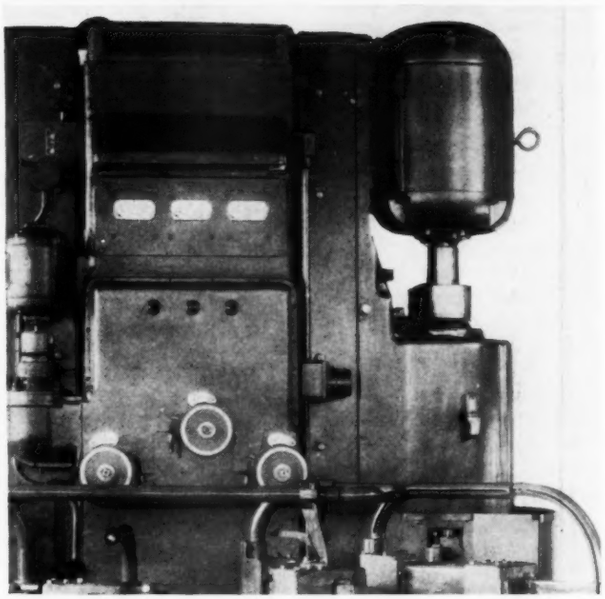




Recording milk temperatures in a batch-type pasteurizer (above) and a continuous pasteurizer (below) automatically controlled by built-in Bristol instruments to secure a uniform product

As in the selection of temperature measuring instruments each type of electrical instrument has individual characteristics that determine its field of application. Whether a permanent magnet, electrodynamic or magnetic induction instrument is used, electrical characteristics of the circuit, and such service conditions as readability, accessibility, temperature and vibration must be considered. Since these factors are





In airplanes, built-in instruments, as in the Boeing transport, are indispensable. In the Hanschett rotary grinder, the instruments, though not indispensable, greatly improve performance

intimately associated with the construction and design of electrical instruments, this phase of the problem must be referred to the instrument specialists. But the designer of the equipment must establish the requirements to be met.

Maximum and minimum values to be read on the dial determine the scale range selected. For steady loads, the full scale value should be about 50 per cent greater than the normal operating value. For fluctuating loads no simple rule can be followed because of differences in individual characteristics of the various types of instruments. The extent and duration of possible overloads likewise influences the selection of both the scale range and the type of instrument.

Vibration and shock also are factors that must be considered by the instrument specialist in selecting the type of instrument. Both the frequency and the amplitude of vibration at the instrument mounting should be determined by the designer as well as shock conditions arising in shipping or installing the equipment.

In normal indoor service the effect of temperature on the performance of an electrical instrument can be neglected. For portable equipment that may be subjected to low atmospheric temperatures, or for applications near ovens or furnaces where high temperatures may prevail, this condition is an important consideration, and the minimum or maximum service temperatures should be established.

The size of the instrument scale is controlled by three factors: distance of reading, space available and sensitivity desired. Long distance reading or high sensitivity require the use of long scales and therefore large instruments. Scales to be used from a distance have large graduations and a large pointer target. Sensitive instruments to be read at close range need fine scale divisions and a knife-edge pointer. Where space available is limited, square or rectangular cases can be used instead of the round types.

In providing a mounting for the instrument, ample space is necessary back of the instrument for the electrical connections, and the instrument must be installed so that it can be removed if servicing is necessary. Instrument cases are available for mounting with the scale flush with the panel or mounting surface, or with the case extending forward from the panel. For convenience in reading the scales, instruments are ordinarily mounted on a vertical surface. For other than vertical mountings the angle of the mounting surface may be a factor for some types of instruments.

Although instrument scales are ordinarily calibrated in terms of the electrical quantity being measured, for greater convenience scales can be calibrated in terms of secondary values. Thus, in electric tachometers consisting of a generator and a voltmeter, the instrument scale can be calibrated in r.p.m. or speed. Instead of merely indicating motor current, an ammeter on a machine tool may have a scale marked in horsepower or in per cent of normal operating load.

In addition to the indicating type, recording electrical instruments are also available, giving a permanent record on circular or strip charts. The recorders can be placed in parallel with the indicating instruments and at some distant location, if necessary. Contact-making attachments can be used on some recording types giving the instrument control functions as well.

Contact-making indicating instruments are also obtainable with contact ratings of several watts. Chattering of contacts is prevented by a magnetic attraction between the contact on the pointer and the stationary contact. After an operation, the pointer must be released by hand or by a reset mechanism before another operation can take place.

Data and information obtained through interviews and correspondence with chief engineers and instrument specialists of: The Bristol Company, Brown Instrument Company, The Foxboro Company, Leeds & Northrup Company, Roller-Smith Company, Westinghouse Electric & Mfg. Company, and Weston Electrical Instrument Corporation.

QUESTION AND COMMENT

A Plea to Instrument Makers

W. C. BACHMAN
Lehigh University

● Anyone who devotes much attention to the subject of engineering measurements must be impressed by the innumerable sources of error which are constantly present. Many instruments and meters are provided with accurately graduated dials whose apparent precision is frequently deceptive to the experienced user as well as to the novice.

Manufacturers' catalogs and instruction booklets usually fail to provide any but the most rudimentary statements of the errors involved. Fundamental principles and chief sources of error are well presented in numerous textbooks on the subject, but no book can possibly discuss all of the products of each manufacturer.

If the maximum utility is to be obtained from any instrument, a complete knowledge of its characteristics is essential. Frequently, operating characteristics are very far from ideal. Measurements must be made under widely diverse conditions. Practical construction difficulties make absolutely precise instruments unobtainable. This is a negligible limitation if the direction and magnitude of an error may be accurately foretold.

Relatively few users possess the facilities necessary for precise calibration under a variety of conditions. They must depend upon the meager information normally supplied or trust their own judgment. When instruments are manufactured in large quantities, it should be possible for the makers to estimate their probable behavior. If a user knows that a certain deviation from ideal operating conditions will cause a probable increase in error of not over 5 per cent, for example, he can immediately decide whether such a deviation is acceptable. A mere warning that an error may result, without a statement of its probable magnitude, may discourage desirable applications of equipment. An expensive, guaranteed, individual calibration is seldom necessary if complete information concerning average operating characteristics is available.

A temperature correction is frequently given, particularly with electrical instruments. This is valuable, but the total correction is often less than other normal errors. Factors such as influence of location, permanence of calibration, consistency of indication, and methods of operation are seldom adequately discussed. When compensating devices are provided, their limitations are rarely explained. Maintenance requirements usually are stated arbitrarily with no explanation of their relative importance. As a result, inconsequential things receive much attention while essential points are neglected.

The solution to the problem must come from the manufacturers. They can greatly extend the usefulness of their products if they will supply more complete explanations in their instructions and, where possible, quantitative estimates of probable errors. The subject of engineering measurements is a technical and highly specialized one. To those who must dabble in its fringes, specific and readily applicable information is invaluable. No one is better able to provide it than the instrument makers, who should be our strongest advocates of more accurate information.

Instruments in Design

To the Editor:

● In sales and engineering work most machine designers do not make sufficient use of tools and instruments that are at hand. Polariscopes, vibrometers, stroboscopes, and strain gages are instruments which have much practical use. Certainly too much rule of thumb design is used, and not enough based on fundamentals and analysis.

On three occasions recently an engineering society was asked to find a man for a responsible position in an engineering department. In each instance the request was for a good man, a well trained man, and a practical man. In trying to get a more specific statement of requirements, it was found that the jobs required men who were thoroughly conversant with basic fundamentals and able to apply them. The requirements were for men who had some experience, but above all, men who could make use of every one of the modern innovations, instruments and tools available for investigation.

Lack of fundamental knowledge of stress distribution has lead to many design failures such as improper keying, improper location of keyway, incorrect specification of key fit. In one design, a pinion split because it was fitted on a taper shaft with the key bottoming in the keyway on the pinion. Such conditions are not at all unusual when designers fail to use modern instruments.

—J. H. GEPFERT
Cleveland, Ohio

The Future of Product Design

WILBUR HENRY ADAMS
Cleveland, Ohio

● In the past "product styling" usually consisted of cleaning the superfluous detail and ornament from an article.

Designers have unconsciously followed leaders who started this face-lifting vogue. The original Standard gas range, for example, is a masterpiece—a step forward and a work of art. Now, however, every stove manufacturer in the country is trying to imitate it.

The same situation holds true for refrigerators. The design of the small General Electric refrigerator is the last word in good taste. It is simple and beautiful. To take off anything would be impossible—to add would spoil. But does every refrigerator have to be white, have chrome hardware, and a black base? And so it is with automobiles. For an automobile to be perfectly streamlined it can assume only the well-known teardrop form, and, all makes will be forced to take on the one common shape. Shouldn't industrial designers try to solve this problem of sameness in design?

One way in which to give appeal to

an object is to add three lines or flutes either through the center or along the sides. Today this "three-line" idea is carried out in automobiles, hardware, adding machines, furniture and household appliances. Now what will the designer do when he is commissioned to redesign one of his own designs? How can he possibly change the design of an article that has been simplified to such an extent that to redesign it would mean to add the ornament that he only recently took off?

Consumers are now completely "design conscious" and will remain so. "Eye appeal" in a product will continue to be one of its greatest selling assets but there must be variety in that "eye appeal." The design problem today furnishes a situation that cannot be settled with a mere wave of the hand.

Industrial design has taken more than one manufacturer from the "red" side of the ledger to the "black." It will continue to do so only if industrial designers can break down this similarity of appearance. Otherwise, the profession will find itself choked to death by its own mistakes.

Shaft Positions in Oil Film Bearings

To the Editor:

● Two articles in *Product Egineering,* one by C. H. Leis in the August, 1934 number and one by R. G. N. Evans in the January 1935 number show opposite directions for the movement of the shaft within the clearance in oil-film bearings. Both of these writers are right, but neither one stated the whole truth.

As explained in a booklet, "Bearings and Their Lubrication," published by the Vacuum Oil Company, the shaft successively takes four different positions during the time it is coming up to speed. At the start the shaft climbs from contact with the journal to the position it would be expected to reach, as shown by Mr. Evans. Later, the shaft moves back to a point somewhat above the starting position, and finally moves over to a position as shown by Mr. Leis.

—H. E. GOLBER
Research Engineer
Miehle Printing Press & Mfg. Company

Localized Lighting on Machine Tools

R. C. HEINMILLER
The Foote-Burt Company

● Recent articles and demonstrations about lighting have emphasized the use of localized lighting to supplement the general illumination of a plant. Lighting units have been designed that are ideal for certain applications but are not as satisfactory for others because of the nature of the work or the design of the machine.

A typical example of the difficulties often encountered is found in the case of the modern motor-driven, radial drill shown in the accompanying illustration. Because of the large head-unit on the arm of the machine, shadows make it difficult for the operator to see clearly the operation of the tool. This is especially true where holes are laid out with a center punch.

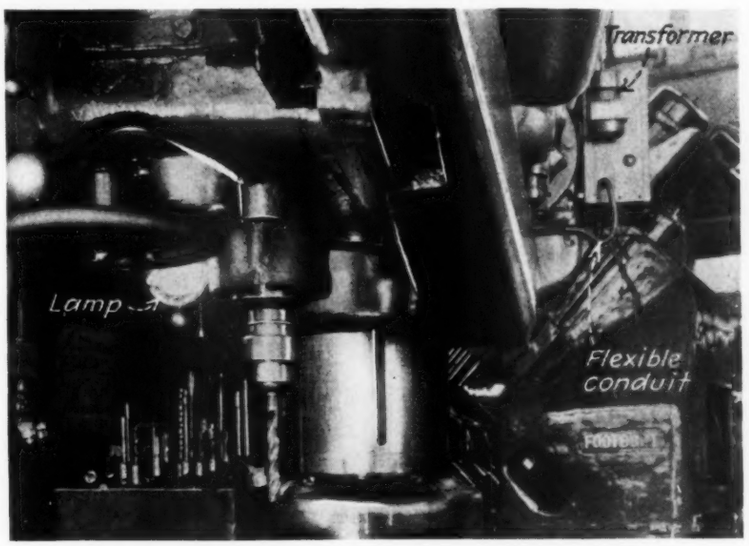
The working area of the drill spindle is large; the maximum spindle radius is nearly 5 ft. and the minimum radius is about 2 ft. Vertically, the spindle will travel travel up to a height of 5 ft. or more. Therefore, any local lighting that is provided must be directed to the spindle through all this working space.

Extension lights may be used, but it is difficult to find a convenient place to hang the light, and the cord may get tangled up in the work or in the machine. Localized lighting built into the machine is necessary.

In the installation illustrated, a small bracket is mounted on the lower side of the head near the spindle to hold the lamp receptacle and a suitable reflector. The wires are run through flexible conduit to the motor switch on the end of the arm. Sufficient slack is provided in the length of conduit for the head to travel its full distance on the arm. A small transformer with a 100-watt rating, is mounted at the motor switch, reducing the 440-volt single-phase current supplied to the motor to 110 volts for the lighting circuit.

While in this instance the application has been made to a radial drill, the transformer idea can be applied to other types of motor-driven machine tools, such as lathes, milling machines, and boring mills.

Every machine-tool manufacturer should develop a built-in light for his type of tool and furnish it on the machine, completely wired with a suitable transformer. Or where single-phase auxiliary motors are used on a machine, as for a tool and cutter grinder, a transformer to supply the correct voltage to the auxiliary motor could be mounted on the machine. This would eliminate the need for running to the machine another circuit in addition to the power circuit.



Illumination is supplied by a localized lighting unit mounted on the drill head of this Foote-Burt radial drill

Too Much Credit for Leather Packings

To the Editor:

● The company connection of the author of the article "Design Proportions for U-Leather Packings" was not stated in the article that appeared in your June number. But judging from the two first paragraphs of the article, on page 224, I conclude that

the author is with a company manufacturing leather.

The very first sentence of the article sounds like the statement of a leather salesman. The author states, "Leather is the only material that has a satisfactory life under high hydraulic pressure." This statement is not true because there are numerous applications where leather would not last any appreciable length of time, whereas asbestos, hemp or other type packings would have an indefinite life. For example, in any application where high temperatures are involved, leather is not satisfactory. Numerous chemicals will affect leather, and so will certain oils.

Considering the good design data and information given in the balance of the article, perhaps the author should be excused for his overenthusiasm in resorting to superlatives. What I cannot understand is why the editor ever left such a sweeping statement in the article.

—O. B. SCHEER
Rochester, N. Y.

[*Editor's Note*] We must admit the correctness of Mr. Scheer's criticisms, but he is incorrect in his assumption that the author is connected with a leather manufacturer. He never has been so connected, but has used leather packing in numerous applications at both low and high pressures. His original manuscript stated specifically that even special leather was suitable only below temperatures of about 200 deg. F., but since Mr. Dorr mentioned this in his previous article and it is also generally known, the editors deleted it in condensing the article to meet space requirements. It was necessary in condensing to delete a number of the author's qualifying sentences. In editing, the term hydraulic was considered in its original meaning, namely, as applying specifically to water. Although this explanation is not an excuse for the lack of accuracy of the introductory paragraph, we are glad to note that Mr. Scheer was pleased with the remainder of the article.

Special Gears With Standard Cutters

To the Editor:

● For the special gear combination specified by James A. Hall on page 149 in the April number, it may be assumed that gears for the proposed ¼ ratio should be cut with the 20 D.P. hob specified for the original pair.

The pitch can be changed to 40 D.P. which gives an addendum of 0.025 in. and a pinion outside radius of 1.000 in. However, it is assumed that load conditions require a 20 D.P.

The data given determine a center distance of 4.875 in., and for a ¼ ratio the pitch radii become 0.975 in. and 3.900 in. irrespective of the pitch used. A standard 20 D.P. pinion will have 39 teeth and an outside radius of 1.025 in. but the given conditions set a limit of 1 in. for this dimension.

One solution for the 39/156 ratio consists in altering the addenda to 0.025 and 0.075 in. respectively for the pinion and gear. The working depth remains 0.100 in., the standard for 20 D.P. This alteration of the addenda is in a direction contrary to that used for non-standard gears; it is always desirable to use a longer addendum on the pinion than on the gear.

This undesirable addendum ratio may be improved by decreasing the numbers of teeth and cutting with the standard 20 D.P. hob, the result of this being a reduction of working depth and, incidentally, an increase in pressure angle which is not objectionable if kept within reasonable limits.

For a ratio of 38/152 let S equal 190, the sum of tooth numbers, and C, the center distance. Also, let α equal the running pressure angle, θ the tangent minus arc for α and F an intermediate value.

$$\text{Cos } \alpha = \frac{\text{Cos } 20 \times S}{\text{D.P.} \times 2C}$$

$$\alpha = 23 \text{ deg. } 43 \text{ min.}$$

$$F = (\theta - 0.0149044) \frac{\text{Cos } 20}{2} + 0.500$$

The reduction of the whole and working depths below the standard becomes $(S \times F/\text{D.P.}) - C$, thus giving a working depth of 0.0883, which may be divided into 0.025 and 0.0633 in. addenda. This results in 1.000 in. for the pinion outside radius and 3.9633 in. for the gear radius. Pitch radii are as above.

If the load conditions permit the pitch to be made finer, a 24 D.P. hob may be used and the further reduction of working depth, subtracted from the gear addendum only, results in still better tooth proportions. If the ratio is made 45/180, the pressure angle is 25 deg. 22 min., outside radii are 1.000 and 3.934 in. for the pinion and gear. The addenda are 0.025 and 0.034 in. for this combination.

—ARTHUR L. WILDER
Wethersfield, Conn.

Journal Bearing Design

To the Editor:

● The article by Victor Tatarinoff, "Safe Loads for Journal Bearings," appearing in *Product Engineering* for December, is liable to give wrong ideas to some readers and to discredit, by partly incorrect application, a method useful in itself for calculating journal bearings. The article gives directions for use in practice without making generally clear the most important relations between the various factors affecting the problem. Such a procedure is all the more faulty when at the same time the sources which the author has used are not given, so that neither deeper insight into the matter nor comprehensive criticism is made possible for the reader. The calculation seems to be built up on vague, or at least insufficiently defined assumptions.

For instance, it is not permissible to speak of bearing clearances as if they were workshop standard fits and at the same time give for them definite figures for load capacities. In reality, there would be available under the actual running temperatures hardly more than half these clearances. The carrying capacity changes considerably, due to the heat expansion and shaft deflection, so that all such supposed accuracies become illusionary.

The article is no doubt the result of much hard and patient work. However, the recommendation for the calculation of the required length of bearing suggests a lack of acquaintance with present-day knowledge concerning bearing design. Such advice would serve designers badly indeed, because it might be the cause of serious failures in practice. The load capacity of a bearing of usual proportions is reduced, and not improved, by an increase in length of bearing. The theory of journal bearings depends for its usefulness not only on thorough theoretical knowledge, but also on many years of practical experience in all ranges of mechanical engineering.

—E. FALZ
Hanover, Germany

To the Editor:

● Curves given in the article were constructed from formulas and suggestions given in the well-known German handbook on machine design edited by Professor Rotscher *(Die Maschinenelemente, Band, 1929)*. The

fundamental formulas were subjected to some modifications to render them suitable for U. S. units. However, in the fundamental formula for N on page 45, a multiplier $1/d$ was omitted.

Although Mr. Falz states that definite values for load capacities cannot be established on basis of workshop standard fits, in many of his reports he recommends the use of "L in B Din Passungen" and on that basis estimates safe loads on bearings neglecting the question of illusionary accuracy. Fundamental formulas of German origin do take into account the effect of heat expansion and shaft deflection. Correction factors given for the ratio of length to diameter in each of the charts in the article include both of these factors.

In his published articles, Mr. Falz is a strong supporter of short bearings, claiming for them lower manufacturing cost, better cooling effect, and higher specific loads because of the decreased shaft deflection. The claim that the load capacity of a bearing of usual proportions is reduced and not improved by an increase in length is based on tests made with Caro-Cronz bushings, in which an increase of specific load was found with a smaller ratio of length to diameter. The results of these tests differ greatly from the results of research work reported by American investigators. (S. A. McKee, "Friction of Journal Bearings as Influenced by Clearance and Length," *A.S.M.E. Transactions*, Vol. 51, 1929, Paper APM 51-15; H. A. S. Howarth, "Journal Running Positions," *A.S.M.E. Transactions*, Vol. 51, 1929, Paper APM 51-3). Even the German manufacturers of bearings do not follow the idea of Mr. Falz.

The greatest disadvantage of a short bearing is the increase in oil leakage through the side clearances. Of course, lubricant delivered by an oil ring will cover the leakage, but tests reported by G. B. Karelitz ("Performance of Oil Ring Bearings," *A.S.M.E. Transactions*, Vol. 52, 1930, Paper APM 52-5) show the unfavorable relation between oil supply and its leakage. Bearing designers today are using a ratio of length to diameter greater than 1.5 with no serious failures in practice. (H. A. S. Howarth, "Current Practice in Pressures, Speeds, Clearance and Lubrication in Oil-Film Bearings," *A.S.M.E. Transactions*, Vol. 56, 1934, Paper MSP 56-2.) It would be interesting to hear the competent opinion of American and English investigators and bearing manufacturers on the possibility of using higher specific loads for shortened bearings.

—VICTOR TATARINOFF
Pilsen, Czechoslovakia

Construction of Nomograms

CARL P. NACHOD
Vice-President, Nachod & U. S. Signal Company
Louisville, Ky.

● In the alignment charts or nomograms for cantilever springs in the November and December numbers the arrangement of the scales spreads them about on the page so that they must be drawn to a small size. By arranging the chart more compactly, as shown in the reference book sheet on page 279 of this number, the scales can be given not only a greater range of values, but also moduli twice as great can be used, increasing the accuracy of calculation.

For equations of the form $A/B = C/D$ the nomogram takes the form of a square in which the four values that satisfy the equation are cut simultaneously from the sides of the square by two index lines at right angles. Each of the quantities A, B, C and D may be any algebraic expression containing one and only one variable with any exponent.

Each side of the chart carries a scale whose equation is:

$$X_A = m \log A \qquad X_B = m \log B$$
$$X_C = m \log C \qquad X_D = m \log D$$

If m is the same for each side, a pair of perpendicular index lines will intercept, on the sides of the square, values that satisfy the equation. For example, in the reference book sheet on page 479 of the December number, the relation between the fiber stress f, the load W, and the length L, width w and thickness h, in inch and pound units, is given as:

$$\frac{f}{W} = \frac{6L}{wh^2}$$

This equation contains five variables, which are reduced to four by introducing an auxiliary variable Q, equal to f/W. For convenience the equation is written:

$$\frac{h^2}{6L} = \frac{1/w}{Q}$$

The four scale equations and their positions are:

$X_A = m \log (h^2) = 2m \log h$ (left)
$X_B = m \log (6L) = m \log L + m \log 6$ (right)
$X_C = m \log 1/w = -m \log w$ (top)
$X_D = m \log Q$ (bottom)

For the positive sign, the scales extend to the right, and upward for ascending numbering. Scales for h, L and Q increase positively while the scale for w is an inverse variable and ascends to the left. In the first equation, the exponent becomes the multiplier for the modulus. If m is made 2.5 in. to fit the page size, then for a range of 1 to 100 the square will have 5 in. sides. The side for h will have a range of only 1 to 10, since its modulus is 2 m or 5 in., but it can be extended as shown, from 0.1 in. through 0.005 in.

In constructing the chart three of these scales are started at the corners as will be explained. The Q-scale is a turning line and need not be graduated; it is common with one scale in the 3-variable nomogram below the square, whose equation is $Q = f/W$, the next scale to be drawn. This equation is rewritten as a product of two factors: $Q \times 1/f = 1/W$. This relation represents the two outer parallel scales Q and f, with W between them. The equations of the scales are:

$$X = m_1 \log Q; \quad X = -m_2 \log f$$
$$X = m_3 \log (1/w) = -m_3 \log W$$

Also, $m_1/m_2 = a/b$ in which a and b are the distances between the scales as shown, and

$$m_3 = \frac{m_1 m_2}{m_1 + m_2}$$

For this diagram $m_1 = m_2 = m = 2\frac{1}{2}$ in. Then $m_3 = m/2 = 1\frac{1}{4}$ in. The scales are:

$$X = 2\tfrac{1}{2} \log Q; \qquad X = -2\tfrac{1}{2} \log f;$$
$$X = -1\tfrac{1}{4} \log W$$

The first scale is the same as the last one in the square nomogram and coincides with it. The second and third scales ascend to the left because of the minus sign. The scale f is started at an arbitrary point and graduated throughout the range.

Assume any values in the original equation such as $h = 0.06$, $L = 6$, $w = 1$, $f = 100{,}000$. From these $W = 1$. Therefore, in the square, a line is drawn connecting 0.06 on h with 6 on L, and from 0.1 on w, a perpendicular is drawn to this line, continuing it to the Q scale. A line drawn through this point on Q, to 100,000 on f, intersects the W scale at the point to be marked 1. The modulus for the W scale is m_2 or $1\frac{1}{4}$ in., and it ascends toward the left. With all the scales determined, and all except Q graduated, the 5-variable nomogram is complete.

Thermostatic

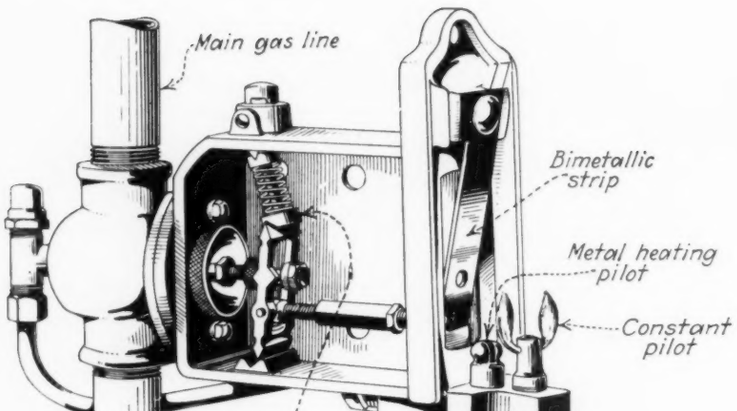


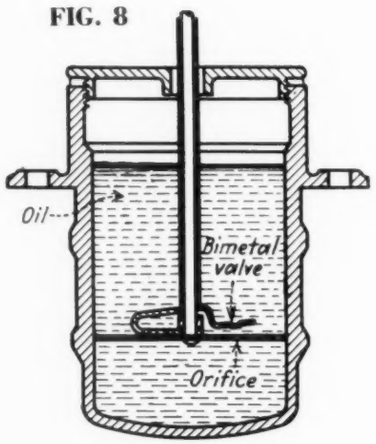
FIG. 11

BIMETAL elements in thermometers, room thermostats, relays, carburetor heat controls and automobile instruments were shown in the first article appearing in the May number. Additional mechanisms shown here are used to compensate for temperature errors in dashpots and thermometers, to control temperatures in automobile engines, hot water tanks and electric irons, and to operate pilot lights in gas burners.

Fig. 8—Oil dashpots used in heavy capacity Toledo scales have a thermostatic control to compensate for changes in oil viscosity with temperature. A rectangular orifice in the plunger is covered by a swaged projection on the bimetal element. With a decrease in oil temperature, the oil viscosity increases, tending to increase the damping effect; but the bimetal deflects upward, enlarging the orifice enough to keep the damping force constant. A wide bimetal strip is used for stiffness so that the orifice will not be altered by the force of the flowing oil.

Fig. 9—In mercury-filled indicating thermometers, expansion of the mercury in a bulb at the end of a capillary line causes the spiral tube in the gage to uncoil, moving the dial pointer by means of a linkage. However, changes in the temperature of the mercury in the capillary and spiral also affect the movement of the linkage introducing an error in the reading. In the Taylor indicating thermometer, compensation for changes in gage temperature is obtained by a flat bimetal strip that forms a part of the pointer linkage. The strip is designed so that its deflections are equal but opposite to the effect caused by changes in gage temperature. Since little load is imposed on the thermostatic strip, the compensating action can be obtained with high accuracy.

FIG. 8



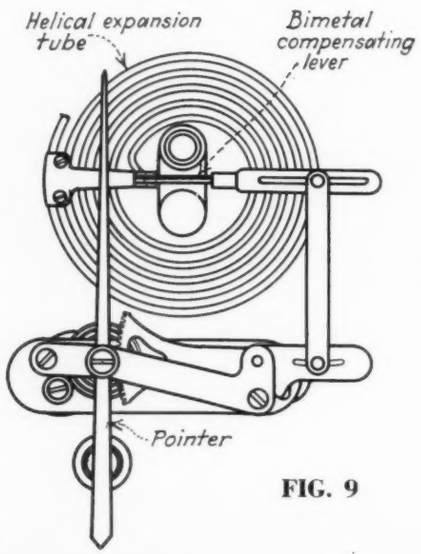


FIG. 9

Fig. 10—In cooling-water thermostats for automobile engines, the water flow imposes a load on the bimetal spiral, and in addition the over-travel caused by continued cooling after the valve is closed sets up stresses which increase as the temperature decreases. Sufficient strength and cross-section to safely withstand these stresses without permanent deformation requires a long flexible element. High accuracy is not obtainable, but in this application a relatively large variation in operating temperature is permissible. In the Chase thermostat, the bimetal element is in the form of a tapered spiral spring which is connected to a rotating valve by a simple linkage. To stabilize the bimetal element, it is subjected to a series of hot and cold treatments at temperatures beyond the normal temperature range.

Fig. 11—When the bimetal element in a gas pilot-light control is placed near the pilot flame, the bimetal is subjected to a temperature

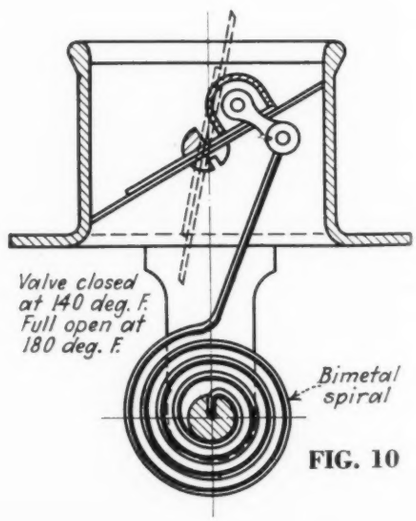


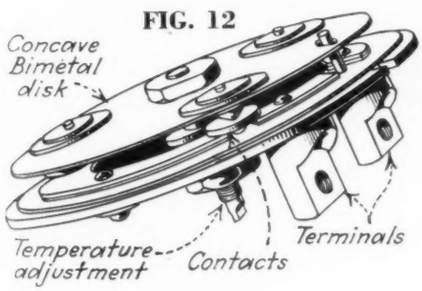
FIG. 10

Mechanisms—II

near its maximum operating range, and in service over long periods of time the valve may become corroded and fail to function when an emergency arises. In the pilot control made by the Patrol Valve Company, operating temperature of the bimetal is reduced and distortion from overheating is prevented by a dual pilot construction. The constant-burning pilot ignites a second pilot which heats the bimetal strip when the thermostatic control calls for heat. The bimetal strip upon heating opens the toggle-operated main burner valve, which, by means of a double-seat construction, reduces the supply of gas to the second pilot, leaving just enough flame to keep the bimetal from closing the valve. Since relatively wide limits for temperature of operation are permissible, the bimetal element is designed to develop sufficient force to operate the toggle spring without the use of high working stresses.

Fig. 12—Toggle action, without separate springs, is obtained in the Spencer disk thermostat. The disk is a saucer-shaped piece of bimetal sheet which snaps itself from a concave to a convex shape at a predetermined temperature. Both the amount of movement and the temperature differential between opening and closing temperature depend on the design of the disk. For greater sensitivity, smaller differential and a larger movement than can be obtained with the plain disk, the bimetal disk is corrugated. Since the disk is small and stores but little heat, it warms or cools rapidly.

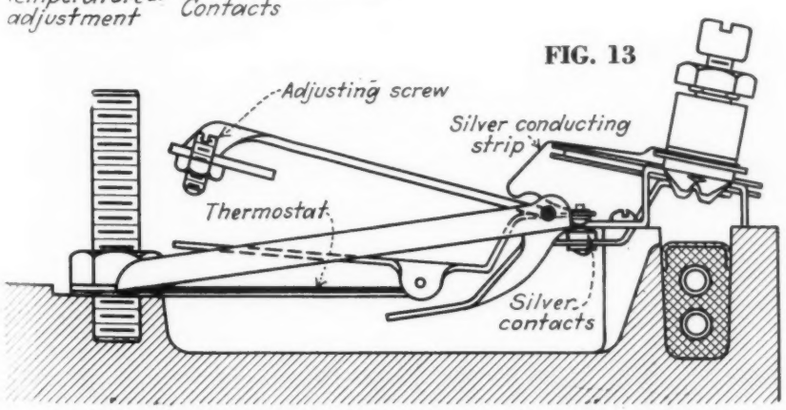
FIG. 12



When used as an electrical control device, insulated silver contacts are mounted on the bimetal disk. In the cold position shown, each of the contacts bridges a gap in insulated plates connected to the heavy terminals. When heated, the disk snaps to a convex shape, opening the circuit through the device at three points.

Fig. 13—Electric irons require a convenient adjustment for the temperature at which the bimetal element opens the circuit. In the mechanism designed by Proctor & Schwartz, a double lever not only permits adjustment of the operating temperature, but also relieves the bimetal strip of any restriction when it cools to room temperature. Since the operating temperature range is high, a heat resisting bimetal material is used in the form of a short, stiff strip. Current is conducted to the bimetal contact through a flexible silver ribbon,

FIG. 13



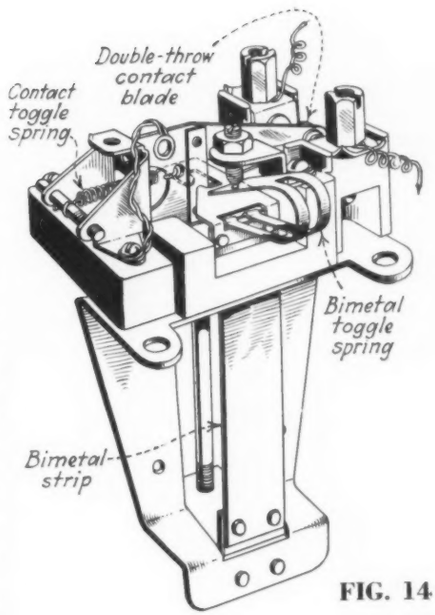


FIG. 14

eliminating the effect of heat caused by current passing through the bimetal strip.

Fig. 14—In the Westinghouse thermostat for electric hot water heaters, a small range of temperature difference between on and off is needed, and to eliminate the necessity for an intermediate relay, the contacts must break a relatively heavy current. These conflicting requirements are met by using a double-toggle mechanism. A light toggle spring on the contact blade keeps the contacts firmly seated until the stronger toggle on the bimetal strip comes into operation.

The bimetal blade is free to move nearly to the dead center position thereby storing energy in its toggle spring before any pressure is applied to the contact blade. Energy released by the toggle spring, when the bimetal blade passes dead center, delivers an impact to the contact blade, breaking loose any slight welding that may have occurred during the previous operation. This thermostat is used as a current-limiting switch, disconnecting one heater as another is connected. Because of the double-toggle design the thermostat contacts will safely interrupt 5 kw. at 220 volts a.c. with a temperature differential of 5 deg. F. or less.

The final article in this series of three on bimetal and bellows thermostatic mechanisms will appear in the September number.

NEWS

Resin Impregnated Wood Develops Remarkable Properties

A NEWLY developed process now makes commercially available wood impregnated with synthetic resin of the phenol and formaldehyde condensation type. In this process the wood is put under a vacuum in a treating cylinder. The wood is then submerged in liquid resin under a pressure of several atmospheres, after which the impregnated wood is taken out and subjected to a cure at 200 deg. F. for about 100 hr. The finished product is marketed under the name Temp-Urd Wood, by the Pyratone Products Corporation of Chicago.

For articles such as handles, wooden bowls, trays and similar products where a high, glossy, durable finish is desired, a second application of the resin material is made. This gives a high transparent finish which brings out the natural grain of the wood. The second application remains on the surface, actually fused to the previously impregnated pores which terminate at the surface. Thus a firm body anchorage is secured, and a remarkably hard finish is produced, offering extraordinary resistance to scratching and abrasion. The very nature of the surface permits sanding and polishing operations to be performed on it without in any way impairing its luster and appearance.

The impregnated wood exhibits its moisture resistance by the fact that it does not swell or warp or become distorted in any way when subjected to moderate moisture changes. However, when the second or double-process is applied, the moisture content is reduced to a negligible quantity and resistance to water is so great that six weeks are required for the double-processed wood to reach a normal moisture content of 8 per cent when completely submerged in water.

Mechanical resistance tests of hard maple that had been given this synthetic treatment, confirmed by the Forest Products Laboratory of the U. S. Department of Agriculture at Madison, Wis., show a 65 per cent increase in the crushing strength at the elastic limit, perpendicular to the grain; an increase of 14 per cent in the fiber stress at elastic limits in parallel compression, and an increase of 16 per cent in maximum crushing strength in parallel compression, as compared to untreated hard maple. Surface hardness was increased 53 per cent.

It is reported that several leading sporting goods manufacturers are using this Temp-Urd Wood process for baseball bats, golf club heads, tennis rackets, polo balls and mallets, fishing rods and lures. The process is now under test with several leading aircraft manufacturers in the treatment of wood propellers, braces and aircraft flooring.

Plating Without Polishing

IT IS estimated that the production costs for polished electroplated parts will be cut in half by a new plating process developed in the research laboratories of Coleman & Attleby, Ltd., Birmingham, England. According to the report, in this new process the article leaves the nickel or electroplating vat with a brilliant polished surface, superior to any mechanical polish. Electroplating becomes an entirely chemical process, the discovery dispensing with the necessity for labor in polishing. It is claimed that this new process is one of the most important ever made in the art of plating and that because of the decreased production costs obtained through this new process it will find a wide application.

Year of Birth of Steel Alloys

MANY engineers, other than metallurgists, may be of the opinion that alloy steels date back only a few years. But, tracing back the history of some of the alloys now in general use will show them to have been in existence more than 100 years ago.

In an address delivered by S. A. Knisely, advertising and sales promotion manager of the Republic Steel Corporation, before the Iron and Steel Group of the National Association of Purchasing Agents, he briefly outlined the chronological development of some of the early steel alloys. Quoting from his talk:

"Some of the descendants of the medieval alchemists got busy shortly after the Napoleonic wars in the early 1800's. Cannon and gun barrels had not been standing up as they should. The result was the first chrome and chrome-nickel alloys.

"The next development followed the Franco-Prussian wars of 1870 in the form of nickel alloys for armor plate. Then in 1876, closer to home, we find chrome steel alloys used in the construction of the famous Eads bridge at St. Louis. This, too, grew out of military necessity inasmuch as the civil war had pointed out the necessity of quick and easy transport across the mighty Mississippi.

"About 1891, France, while carefully hiding her famous 75 mm. gun, did reveal to America the latest developments in chrome nickel alloys—developments which revolutionized the navies of the world.

"At the St. Louis World's Fair in 1904 we find tungsten entering the picture in the form of high speed tool steels, and we begin for the first time to find other than military necessity inspiring the researchers.

"The first big commercial development, however, started in 1905 as the result of the wreck of a French racing car on Daytona Beach, Florida. Henry Ford was watching that race. He was early on the scene of the crash. His searching eyes quickly noted that certain parts of the mechanism were undamaged despite the terrific stress to which they had been subjected, and he knew that in an American-made car the same parts under the same stress would have fractured. Mr. Ford bought that wreck and in the research laboratories that are today a part of Republic Steel Corporation was begun the metallurgical and chemical experimentation which may be said to have heralded this mighty age of alloy steels and irons.

"The world war found molybdenum steels entering the picture as a light weight covering for German tanks. Also, high manganese steels were developed for use in helmets.

"Generally speaking, 1912 seems to have been a turning point. Previous to this the emphasis was placed on physical properties and a desire to improve them. Subsequently, more attention has been given to corro-

sion resistance. This has continued as economic considerations have strengthened the desirability of longer life in ferrous metals. We are now more concerned with what Sir Robert Hadfield, the eminent British metallurgist, estimates is a three billion dollar annual loss due to rust and corrosion.

"As a result we find copper steel and copper molybdenum iron alloys reaching a point of high development and, in what appears to be the crowning achievement of them all, the rapid and wide adoption of that highest of the 'high-hat' steels—the chrome and chrome nickel alloys referred to universally, but sometimes inaccurately, as stainless steels."

Mr. Knisely then told about the recent metallurgical achievement in the laboratories of the Republic Steel Corporation in the development of Bessemer steel with improved cutting qualities, and the Republic's "Double Strength" high tensile, high corrosion-resistance steel.

Nominations Are Announced

NOMINATIONS for officers of the American Society for Testing Materials, for the year 1935-1936 have been announced. Official notice of election will be given at the first session of the A.S.T.M. annual meeting, June 25, in Detroit.

H. S. Vassar of Irvington, N. J., laboratory engineer of the Public Service Electric and Gas Company, has been nominated for president. He is now completing a term as vice-president of the A.S.T.M. and is active in the work of A.S.T.M. Committee D-9 on Electrical Insulating Materials, of which committee he was chairman from 1926 to 1930. He is also serving on Committee D-11, on rubber products.

A. E. White, professor of metallurgical engineering and director of the department of engineering research of the University of Michigan was nominated for vice-president to serve a term of two years. Professor White is active in the work of several A.S.T.M. committees in the metal field and is chairman of the steel committee group on materials for high temperature service. He was the first president of the American Society for Metals and is past chairman of the research committee, American Society of Mechanical Engineers.

Nominations for members of the executive committee to serve a term of two years include W. H. Graves, chief metallurgist of the Packard Motor Car Company. He is a member of several A.S.T.M. committees and active in the work of other societies, including the S.A.E., A.S.M., and American Chemical Society. Others nominated for members of the executive committee are: R. L. Hallett, of the National Lead Company; N. L. Mochel, metallurgical engineer of the Westinghouse Electric & Manufacturing Company; H. H. Morgan, manager of Rail & Track Fastenings Department, of the Robert W. Hunt Company; and W. R. Webster, chairman of the board, Bridgeport Brass Company.

Plan to Enhance Professional Status

AS A part of its plan to enhance the professional status of the engineer, the Engineers' Council for Professional Development has undertaken to define the minimum qualifications of education and experience, the fulfillment of which will entitle an engineer to be recognized as such among his fellows and in his relations with the public.

Through its Committee on Professional Recognition, on which the five national Engineering Societies and the National Council of State Boards of Engineering Examiners are represented, the E.C.P.D. has proposed a "minimum definition of an engineer," and a "program of certification into the profession."

The definition of an engineer, as proposed by the E.C.P.D., sets up minimum qualifications of technical education and practical experience, supported by examinations designed to establish the individual's ability to be placed in responsible charge of engineering work and to render him a valuable member of society. These proposals are now before the governing boards of the constituent bodies of the E.C.P.D. When approved they will provide the criterion and the mechanism for professional recognition of engineers.

The certification program recognizes the fact that the equivalent of a "grandfather clause" must be applied to permit automatic certification of those who are now recognized and accepted as engineers by legal authorities and by the profession. It also contemplates a reasonable transition period for the progressive adjustment of requirements and tightening of standards until the full program of E.C.P.D. for certification can be put into effect. Thus licensed engineers and certain members of technical societies will be automatically eligible to receive certificates, according to a chronological plan, up to January 1, 1938, at which time the formal certification will be put into effect. When that goal is reached it is hoped and expected that certification of an engineer by E.C.P.D. will set a minimum standard of professional training and experience by which he will be accepted and recognized among his fellows and in his relations with the public.

MEETINGS

American Foundrymen's Association—39th annual convention, Royal York Hotel, Toronto, Canada, Aug. 19-23. C. E. Hoyt, secretary, 222 West Adams St., Chicago, Ill.

Machine Tool Show — Public Auditorium, Cleveland, Ohio, Sept. 11-21. F. F. Selbert, secretary, 1220 Guarantee Title Bldg., Cleveland, Ohio.

Permanent Exhibit of Metals and Plastics

ON September 1, a permanent exhibit of metals and plastics is to be opened at Rockefeller Center, New York, by Metal Products Exhibits, Inc. The exhibit will feature alloys, ferrous and non-ferrous metals, plastics, finished and semi-finished parts made from these materials, finishes for metals and plastics, manufacturing processes, designs, styling, etc. It will occupy the third floor of the International Building, the latest addition to the Rockefeller Center building program.

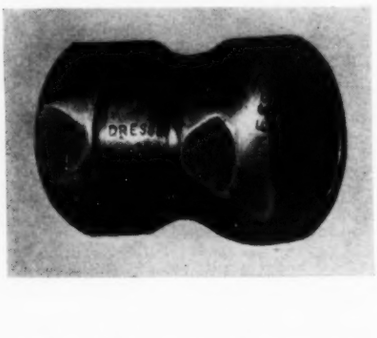
The expressed purpose of the Metal Products Exhibits is to enable executives, purchasing agents, and designing engineers of all industries using metal and plastic materials and parts to keep their knowledge of these products complete and up-to-date. It will be the only one place where all these materials can be seen and examined, where data concerning their properties, applications and sources of supply can be obtained, and where information on newly developed materials and products will be available.

The officers of Metal Products Exhibits, Inc., are: president, F. P. Cummings; vice-president and treasurer, O. H. Simonds; vice-president and general manager, Herbert R. Simonds, products engineer, and formerly associate editor of several magazines serving the metal working field.

New Materials and Parts

Compression Coupling

For making a tight, flexible connection on plain end conduit pipes and tubes. It is unnecessary to thread, groove or flare the pipe or tubing. The union is composed of a coupling body, two armored gaskets, gasket retainers, and octagonal nuts. It is said that the gaskets assume a permanent resilient seal and allow the pipe to vibrate, expand, contract or deflect without strain on the pipe or injury to the joint. The gaskets will withstand temperatures to 200 deg. Piping need not be cut to exact lengths. Available in sizes of $\frac{3}{8}$ to 2 in. steel pipe and furnished either black or galvanized. S. R. Dresser Mfg. Co., Bradford, Pa.

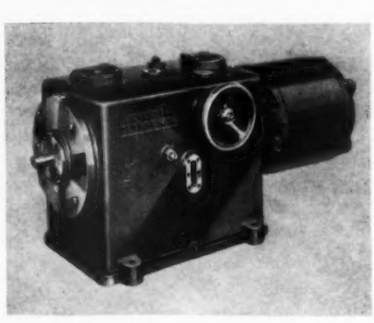


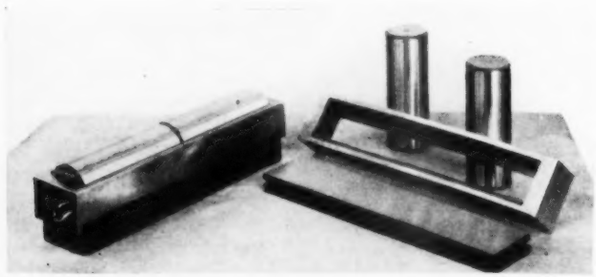
Anti-Friction Bearing Roller Aligner

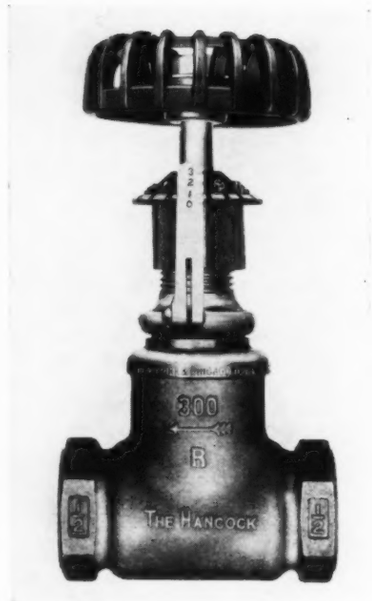
Is used in conjunction with anti-friction bearings when bearings are mounted on the necks of steel and paper mill rolls. A hardened steel plate is fastened in a groove in the chock or bearing member, and a similar plate is fastened at the bottom of the housing. Between these plates is a roller which is divided into convenient lengths, held in a bronze cage. This assembly is located by springs, allowing the chock to tilt angularly by means of the anti-friction motion of the rollers, so as to distribute the load over the entire length of the anti-friction bearing. It is claimed that bearing life is increased and that bearing pressure through deflection is not concentrated on the corners of the anti-friction bearing rollers nearest the roll body. The Bantam Ball Bearing Co., South Bend, Ind.

Hydraulic Variable Speed Transmission

Infinitely variable speeds of 5 to 750 r.p.m. can be secured by turning the handwheel which varies the stroke and delivery of the multiple piston type pump. Additional adjustments permit speeds up to 2500 r.p.m. Hydraulic, mechanical or electrical remote control can be substituted in place of the handwheel. It is said that the power required is always at a minimum regardless of load because the torque is automatically controlled without use of by-passing the oil. Input and output shafts can run in either direction. The unit is driven by a direct connected, 1,200 r.p.m. motor, and does not require belts, pulleys or additional speed reducers. Furnished in sizes of 6 hp. output for continuous duty at 1,000 lb. per sq.in., and $7\frac{1}{2}$ hp. intermittent service at 1,250 lb. per sq.in. Vickers Incorporated, 1400 Oakman Blvd., Detroit, Mich.







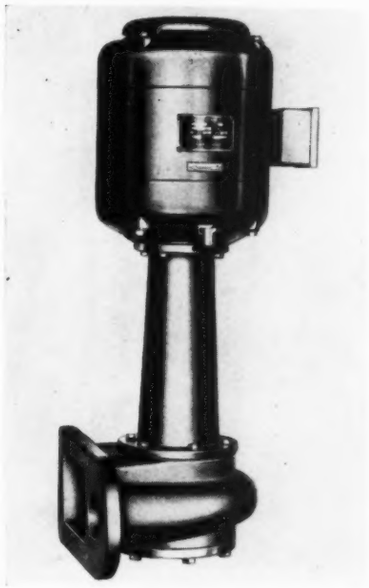
Micrometer Adjusted Control Valve

This "Flocontrol" valve is so arranged to allow the flow through the valve to be proportional to the number of turns of the handwheel. The micrometer adjustment is graduated to $\frac{1}{10}$ of a turn. When the valve is set at two turns open the flow will be twice that when only one turn open. For use with steam, oil, water or gas and available with bronze bodies for pressures up to 300 lb. Made in sizes for $\frac{3}{8}$ to 2 in. pipe with either globe or angle type valve. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

Pipeless Pump

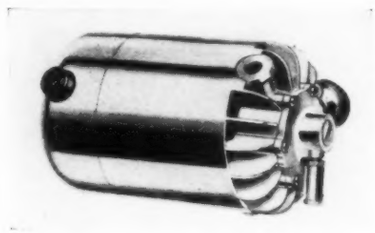
Is attached to machine with five capscrews without piping, hose or tube connections. The intake supply flows into pump by gravity through an opening in the mounting pad on the bed. The discharge is transmitted to pipe or tube which is threaded, caulked or expanded into a hole in the bed opposite the pump discharge port, thereby confining all piping to the inside of the machine. Pump is mounted vertically and is driven by a 1 hp., 1,725 r.p.m. motor. Impeller shaft is ball-bearing mounted. It is said that no

stuffing boxes or relief valves are required. Pump capacity is 150 gal. per min. The Ruthman Machinery Co., Cincinnati, Ohio.



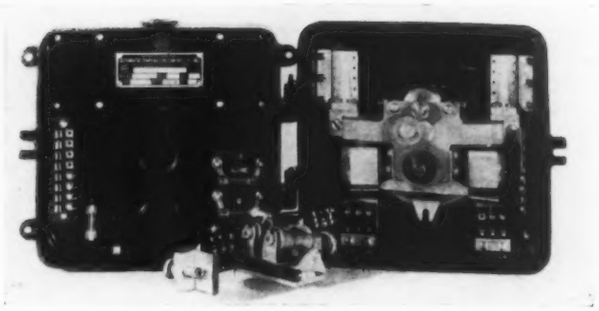
Compressor Motor

Air-cooled combination motor and compressor for paint, lacquer and insecticide sprayers. Universal type motor has $\frac{1}{10}$ hp. rating, operating on a.c., 0 to 60 cycles or on d.c. The compressor develops a dead end pressure of 20 lb. with an air velocity of 650 ft. per min. at the $\frac{1}{4}$-in. discharge vent. Weight of motor is $3\frac{3}{4}$ lb. and is adaptable to small devices using a light, portable compressor. The Dumore Co., Racine, Wis.



Time Control

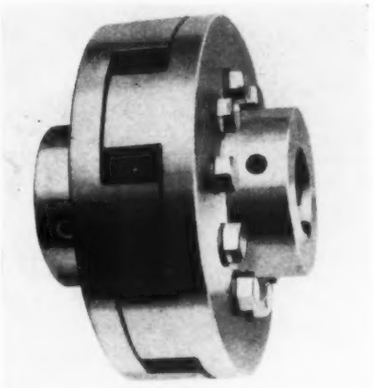
For repeating one or two operations or processes as often as desired with either the same or different time period between successive cycles. The time cycle and the interval between successive cycles are said to be infinitely adjustable with an accuracy of setting within split scale dial dimensions. Parts have been so grouped on the chassis that adjustments can be easily made or parts removed without disturbing wiring. Settings are



claimed to remain accurate despite vibration. Available for 110 volts a.c. or 220 volts a.c. when ordered. Automatic Temperature Control Co. Inc., 34 East Logan St., Philadelphia, Pa.

Flexible Coupling

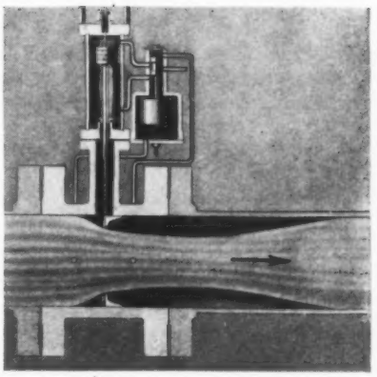
Has free-floating load cushions mounted on removable studs between jaws. Cushions are in plain sight at all time for inspection purposes and can be removed or replaced when necessary without dismantling coupling. Three types of cushions available are, Metalflex, made of brake-lining material and used on excavating machinery, steel-mill equipment, and locations exposed to extreme weather;



Oak-tanned leather for sustained loads and where misalignment exists; and Multiflex, made of rubber-duck fabric for use with fluctuating loads and where high resilience is required. Rated at 18 to 1,500 hp. at 100 r.p.m., 3 to 10 in. diam. bore. No lubrication is required. Lovejoy Tool Works, 5019 West Lake St., Chicago, Ill.

Flow Meter

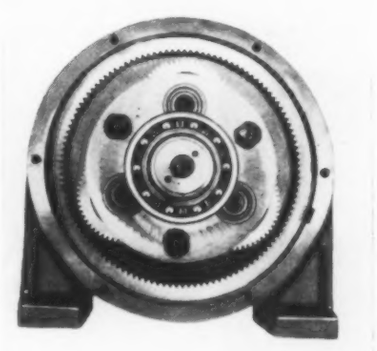
Known as "Elgin Isometer," this meter has a varying orifice for measuring the flow of gas, steam, water, oil, or other liquids. It is said that a constant pressure drop is maintained and that the flow can be determined to



as low as $2\frac{1}{2}$ per cent of meter capacity. It is also claimed that pulsating flows can be more accurately measured. The gate and metering units are electrically driven and by changing the orifice gate movement into an electrical impulse, indicating and recording meters can be remotely located. The actuator consists of a flanged cylindrical section incorporating the variable orifice. The actuator is located in the pipe line and utilizes full line pressure. Elgin Softener Corp., Elgin, Ill.

Speed Reducer

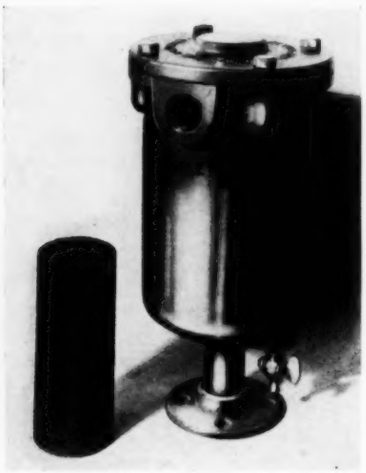
Plain and motorized speed reducers are for either horizontal or vertical mounting. Said to give efficiencies as high as 97 per cent and to withstand overloads with efficiencies not dropping below 90 per cent. Three types are available, planetary type in ratios up to 20 to 1, the gyrating type in ratios of 120 to 1, and a special



group of the gyrating type, with ratios of 120 up to 180 to 1. Larger reductions can be furnished by coupling the reducers in tandem. Sizes of ¼ to 50 hp. are available. Sier-Bath Gear Co., 640 W. 58th St., New York, N. Y.

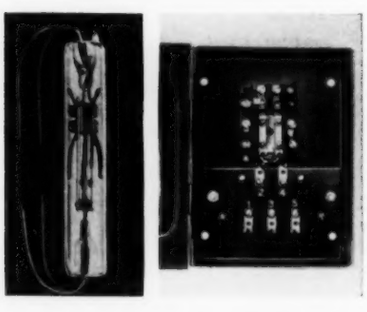
Air Filter

For separation of water, oil or other foreign materials from compressed air. The unfiltered air enters an orifice in the upper rim of the shell and circles around the inner rim at high velocity throwing out all liquids by centrifugal force into vertical slots. As its velocity slows down, the air approaches the center axis and passes through the walls of a filter stone composed of aluminum oxide cystals mixed with a ceramic bond and molded into the shape of a tube with one end closed. The filter tube can be cleaned in any oil solvent every two weeks. A spare tube is furnished. R. P. Adams Co., 220 Delaware Ave., Buffalo, N. Y.

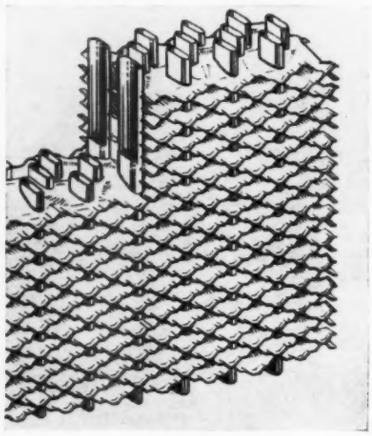


Sealed Thermal Timing Relay

Type R-4 thermal relay, completely sealed in a glass vacuum tube, operates a magnetic contactor. The relay can be calibrated to operate with a delay of a few seconds or several minutes. There is said to be no destructive arcing and that oil or dirt cannot foul the contacts. There are no working parts which require cleaning, lubrication, adjustment or replacement because of wear. The thermal relay is mounted with the magnetic contactor in a standard switch box. Available for use of a.c. or d.c., and may be used for sequence closing of two or more circuits and for starting compressors for air conditioning in sequence. Electrical Controls Div., Thomas A. Edison Inc., Orange, N. J.



Twin Core Radiator

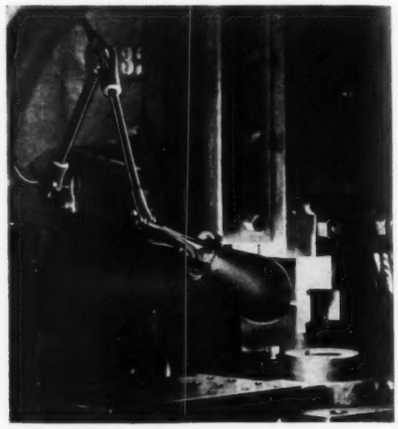


"Hexcel Twin Core," in which the tubes and fins are made of copper is said to be resistant to surface crushing or bending. The fins are of telescopically, interlocked construction, to relieve the elongated tubes of stress and strain. It is claimed that the support of the structure is not dependent on the tubes, and that twisting and weaving strains do not react on the tubes. Double lock seaming and tinning are said to make the tubes self-compensating to freezing pressures. These radiators can be adapted to unit power plants, compressors and automotive and aircraft installations. Hexcel Radiator Co., Racine, Wis.

Revolite Materials

A flexible form of laminated cloth or paper treated with special bakelite resinoid. It is said that laminations as thick as ⅛ in. can be bent over a ¼ in. rod without cracking or splitting or being affected in any way and to be as resilient as medium-soft rubber. Available in various thicknesses, depending on the fabric or paper, and the number of laminations used. Different materials can be laminated together such as fabric and paper. This material can be used as acid-proof linings, diaphragms, packing rings and gaskets, radio parts, vacuum brake parts, belting, upholstery, and insulation. The Revolite Corp., New Brunswick, N. J.

Industrial Machine Lamp



For attachment to machines. The bracket is equipped with three ball and socket joints so that light can be placed in any position. Bracket is made of steel tubing, inclosing light cord. It is said that the wire cannot break at the joints regardless of lamp position. An aluminum shade, claimed to give ample protection to the light bulb is so shaped that bulb can be changed with removing shade. The Fostoria Pressed Steel Corp., Fostoria, Ohio.

Two Pressure Valve

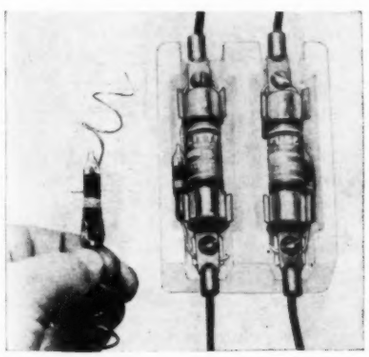
Has full line pressure on the work stroke and reduced pressure for the return or idling stroke. Return stroke pressure can be adjusted from zero to full line pressure after valve is installed. Said that difference in pressure affords a saving in air consumption. Can be set and sealed against tampering after installation. Ross Operating Valve Co., 6478 Epworth Blvd., Detroit, Mich.

Mechanical Shaker

For imparting a horizontal shaking or screening motion to a conveyor, sieve or any other unit requiring such motion. Two weights are geared together to rotate in opposite directions at the same speed. The unit is made dust, oil and fire proof and it is said that 95 per cent of the rotative weight is effective. The unit may be direct or belt driven and two or more units may be operated in parallel. Ajax Flexible Coupling Co., Westfield, N. Y.

Ded-Fuse Tattelite

A small neon lamp and casing designed to show instantly when and where a fuse is blown. Is connected



in parallel with the fuse and draws no current until the fuse is blown. Can be used with any size cartridge fuse for circuits of 100 to 550 volts, a.c. or d.c. Lights on 0.0005 amp. current. Is $\frac{5}{16}$ in. diam., $1\frac{3}{4}$ in. long and has a 6-in. connecting lead at both ends. Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill.

Molded Plastic Material

For molded plastic parts requiring sanding, machining or repolishing operations. This new "Durez" material is used for machine parts, instrument cases, telephones and decorative objects. Said to have a depth of color which permits polishing to a satiny luster even after grinding off the natural surface. Claimed to have a flexural strength of 10,000 lb. per sq.in., and a compressive strength of 28,000 lb. per sq.in., and to mold on regular cycles. General Plastics, Inc., North Tonawanda, N. Y.

Air Filter Replacement

Improved "Dustop" air filter is made of a series of coarse and fine mats of glass fibers. These fibers, laid down by machine, are bonded to each other and are said to form a semi-rigid mat of filter pack density. The dust-catching adhesive bond is said to have a surface tension four times that of engine oil. The melting point of the bond is claimed to be 540 deg. F. and to be effective to 23 deg. below zero.

The filter is fire-resistant. Air leaving the filter is said to be odorless. Owens-Illinois Glass Co., Toledo, Ohio.

Vibration Eliminator

Is fastened to each foot or supporting part of the machine or motor. Consists of a base stamping, supporting housing and a disk of natural cork. This cork is said to maintain its efficiency during the entire life of any machine, is not affected by water, oils or temperature changes and will not take a permanent set under excessive loading. It is also claimed that the cork insert has a time lag in

its return after being compressed which prevents objectionable bouncing action. Made in three sizes to support loads of 65 to 100 lb., 100 to 200 lb., and 175 to 375 lb., all models being 2 in. in height. The Vibration Eliminator Co., 41-26 37th St., Long Island City, N. Y.

MANUFACTURERS' PUBLICATIONS

Alloy Steels—The Timken Steel & Tube Co., Canton, Ohio. "Timken Steel Specifications" single page chart, 8½x11 in. Lists all S.A.E. analyses and standard and special analyses of electric furnace and open-hearth steels manufactured by Timken. These include round, square, rectangular, and hex shapes and tubing.

Ball Bearings — Ahlberg Bearings Co., 321 E. 29th St., Chicago, Ill., announces the revival of their house organ, "Ahlbearfax," a small magazine that "has grown up and the editors have hit on a plan for its contents which should make it one of the most interesting, helpful and educational publications covering these particular fields of endeavor." Anyone wishing to receive the monthly issues should write to the above address.

Ball Bearings—The New Departure Mfg. Co., Bristol, Conn. "Tenth Edition—Dimensions, Load Data and List Prices," 144 pages, 5½x8½ in. Single and double row ball bearings of all types and sizes and for numerous purposes are listed and thumb indexed. Typical mounting drawings, standard lock nuts and washers, felt seals, bearing selection information and tolerances are included. Also pages 3 and 4 for "Industrial Applications" reference book showing in cross section various lathe spindle mountings.

Corrosion-Resistant Steel — Firth Sterling Steel Co., McKeesport, Pa. Booklet, "Sterling Nirosta Steels," 4 pages, 8½x11 in., describes four types, giving chemical and physical properties, heat-treatment, and cold working. Typical applications are given including specifications for wire springs.

Conveyor Belt Self-Aligning Idler—Link-Belt Co., Indianapolis, Ind. Folder No. 1408, 6 pages, 8½x11 in. Illustrating a pulley assembly for troughed conveyor belts. Upright guide pulleys keep belt in place. For belts 14 to 48 in. wide. Dimensioned

outline drawings and other engineering data included.

Motor Driven Pumps — Allis-Chalmers Mfg. Co., Milwaukee, Wis. Leaflet, No. 2199, "A Useful Pumping Unit for Every Industry," 4 pages, 8½x11 in. Construction details with cross-section photographs, various installations and numerous types of motor driven pumps are shown.

Screws — The Holo-Krome Screw Corp., Bristol, Conn. Booklet, "Fibro-Forged Screws," 27 pages, 8½x11 in. Socket head cap screws, hollow set screws, pipe plugs and stripper bolts are listed with sizes, dimensions and weights. Standard set screw points are shown with line drawings. Various application photographs and screw thread data are also included. Inspection methods as used in this factory are illustrated and materials and physical properties are discussed.

Spra-Bonderite—Parker Rust-Proof Co., 2177 Milwaukee Ave., Detroit, Mich. Folder, 4 pages, 8½x11 in. A new method of applying Bonderite, showing the various sections of the units used for cleaning, rinsing, Spra-Bonderizing and drying for treatment of metal to be painted or enameled.

Tapered Roller Bearings—The Timken Roller Bearing Co., Canton, Ohio. Third edition of "The Timken Engineering Journal," black clothboard loose-leaf ring binder containing 260 8½x11 in. pages. Includes a description of the various types of Timken bearings, and technical data, load calculations, bearing selection and other information pertinent to the mounting, use and maintenance of the bearings. There is also data on shims, locknuts and washers, annular groove-closures and tubes. As a supplement there are seven special sections on: mine cars, conveyors, shop trucks, cranes, aircraft, machine tools and farm equipment. Specifications for lubrication are also included. As in previous editions a section of individual dimension sheets is included which shows all single row bearings in full and half sized cross sections. These can be removed from the book and used for tracing. This manual, compiled for the use of engineers and machine designers, supersedes all previous editions.

Tubing — Summerill Tubing Co., Bridgeport, Montgomery Co., Pa. Catalog and data book, 55 pages, 8½x11 in. In the compilation of this material, special emphasis is placed on the versatility and adaptability of seamless tubing. It suggests to designing engineers new uses where accuracy, finish, delicacy, uniformity, durability, high strength and light weight are desired factors.

There is much information in this book relative to shapes, tolerances, physical properties, machining, forming and heat-treatment. Tubing is listed for aircraft, hypodermic needles, golf shafts, fishing rods, pressure gages, temperature control and recording equipment, tubing for oil wells, heat transfer, fuel injection, and radio tubes. Several pages are devoted to the new S.A.E. steels, showing the numbering system and chemical compositions. Miscellaneous formulas and weight table for tubing from $\frac{1}{16}$ to 6 in. diam. are given. Hardness conversion tables and definitions of terms relating to physical properties and heat-treatment are also included.

Wire Cloth — Newark Wire Cloth Co., Newark, N. J. Catalog No. 32, 4½x7 in. A 104-page handbook on woven wire screens and metallic filter cloth. Numerous pages are devoted to scale photographs and line drawings of various mesh screens and cloth. Tables and selection and testing methods are given. Various wire materials for different kinds of acids are listed. A glossary of wire cloth terms, classification of square mesh wire cloth and how to order, are included.

BOOKS AND BULLETINS

Standard Gear Book

Reginald Trautshold. 314 pages, 6 x 9 in. 140 illustrations. Blue clothboard covers. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $3.

This first edition is really a modernization of "American Machinist Gear Book" by Charles H. Logue, published 25 years ago. It gives the facts behind the important advances in commercial gear production of the last quarter century and reiterates the basic principles upon which the operation of modern gear generating machines and the art of gear designing are founded. However, much of the historical background found in "American Machinist Gear Book" was omitted to make room for the most recent developments in gear cutting.

The book is divided into six sections and has a 64-page appendix of working formulas and tables on gear design. Various tooth forms are discussed. Speeds, power, gear proportions and design are taken up in two chapters. Calculations and formulas are given for spur, straight and spiral bevel, hypoid, helical and herringbone spur gears in four sections. Worm and internal gearing are covered in two chapters. Materials and heat-treatment for gears include the A.G.M.A. standards. Planetary gearing, gear units, methods of production, rolled gearing and measurement of gear teeth are each discussed in separate chapters.

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Enamels

Andrew I. Andrews. 381 pages, 6x9 in. 124 illustrations, 62 tables. Dark red clothboard covers. Published by The Twin City Publishing Co., Champaign, Ill. Price $5.50.

In addition to the properties of vitreous enamels, the details of preparation and application are given in complete form, including in one volume, reference material on all phases of enameling. The title of the book "Enamels" refers to a thin layer of glass fused to a surface of metal. Enamels of many types for surface protection, appearance and decoration are described.

Following a brief historical chapter and a discussion of raw materials, a chapter of 30 pages brings together extensive data on physical properties, opacity and materials of general interest to engineers. A chapter on iron and steel gives an elementary review for uninformed readers in the industry and also includes sections on the design of castings for enameling, composition of steel sheets for enameling and data on forming. Preparation of metal surfaces for enameling processes is the subject of a 50-page chapter presenting information on many factors that must be considered in the design of enameled parts. The remaining chapters, except for the concluding one, cover subjects of primary interest to the enameler. Tests for physical, mechanical and chemical properties, and a description of types of defects are given in a detailed treatment in the closing chapter. An appendix of 10 pages includes tables useful in enamel manufacturing and the index of 17 pages is unusually complete.

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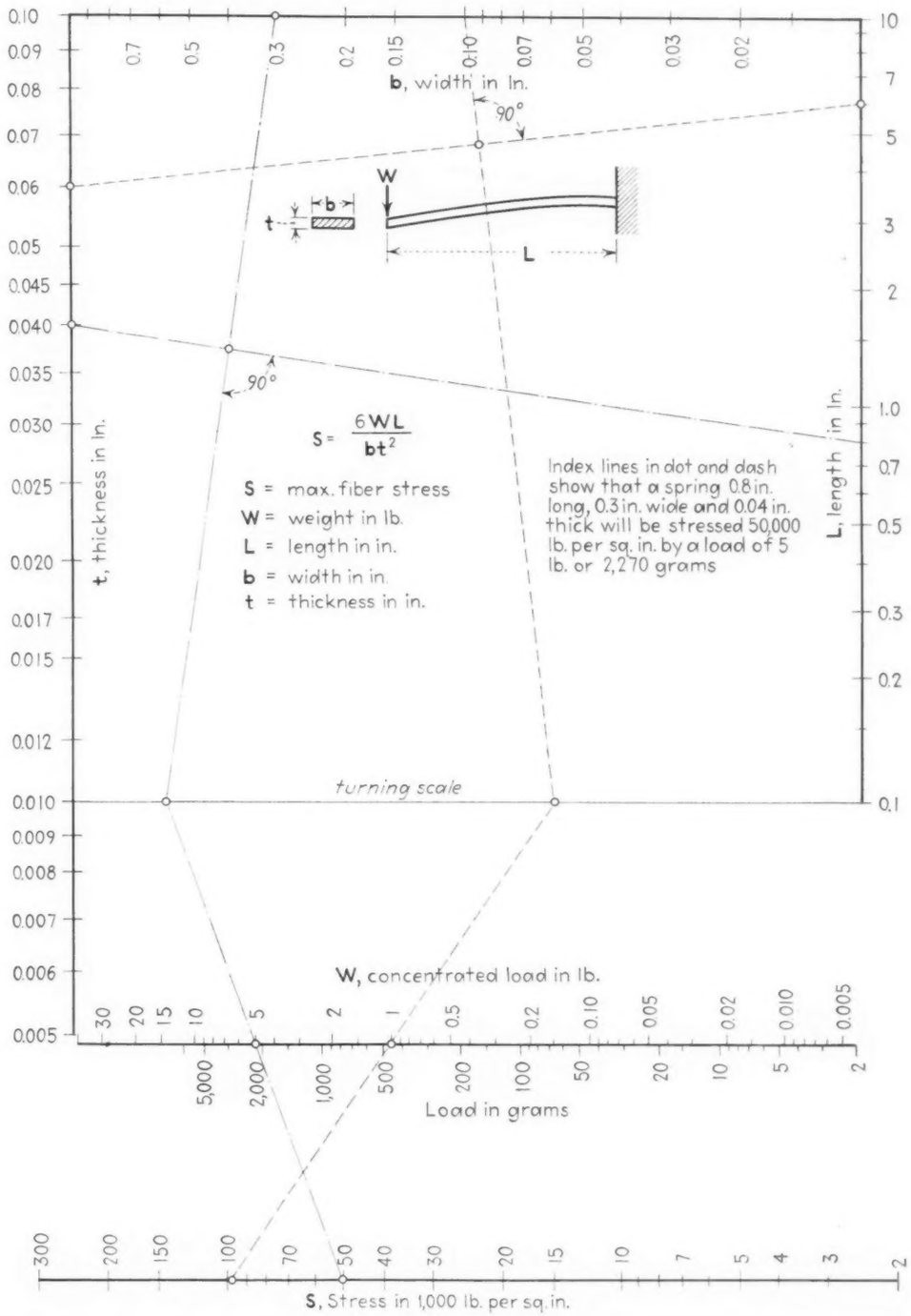
Aircraft Engines

The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Directory of Aircraft Engines, 80 pages, 8½x11 in., paper covers.

This 1935 edition contains photographs and specifications of 64 American and 13 European aviation engines. Particular reference to materials of construction is made, especially of parts where high strength with minimum weight is required. The parts which are made of nickel alloy are listed with each engine, most of these parts having the SAE material specified. Special features of the engine design, materials used for various parts other than those of nickel alloy, accessories and weights are also listed. Engines are indexed for 500 hp. and over, 150 to 500 hp. and those less than 150 hp. Diesel engines are also included.

Stresses in Cantilever Beams

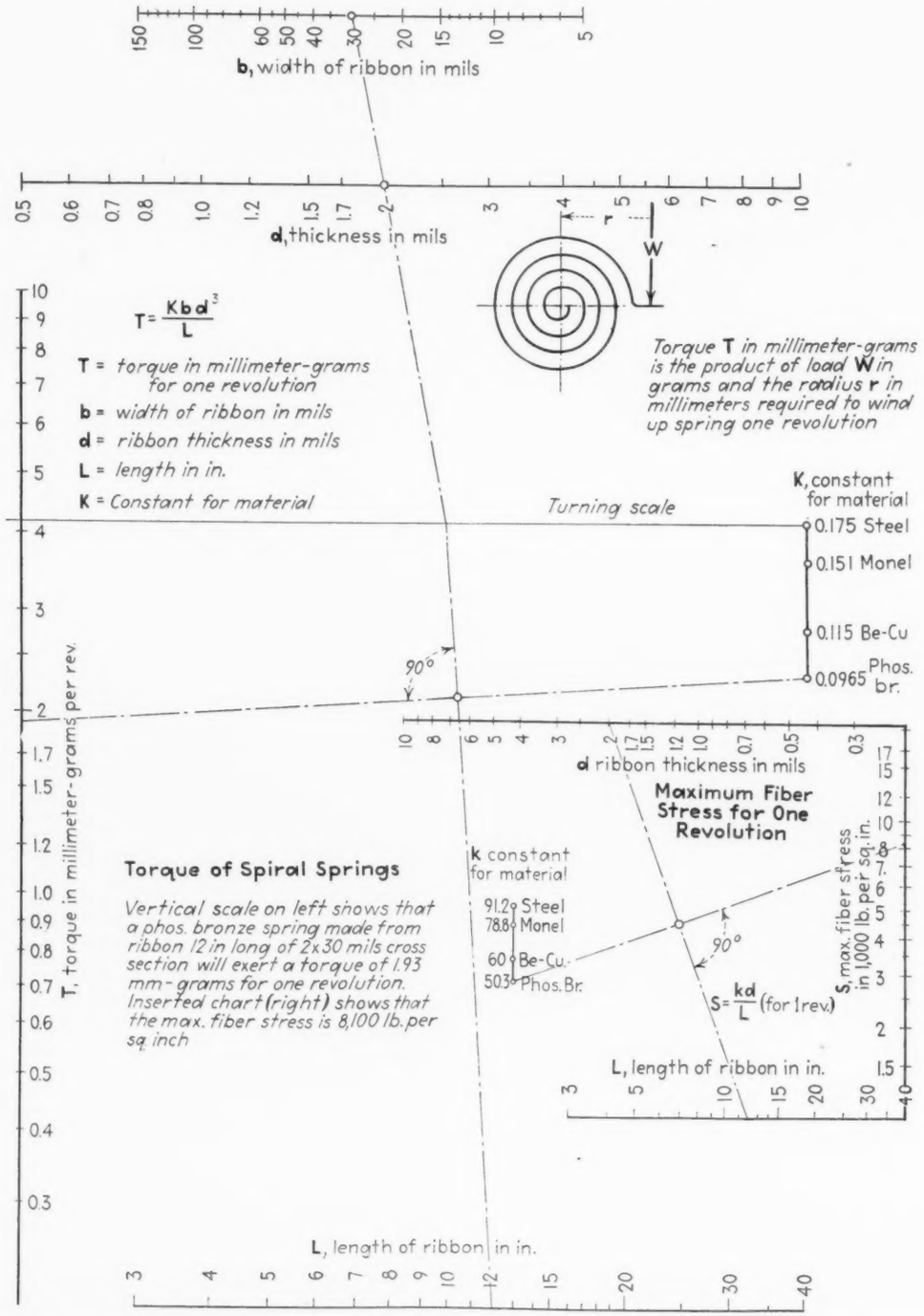
CARL P. NACHOD
Vice-President, Nachod & U. S. Signal Company


b, width in In.
90°
W
t
b
L
90°
$S = \frac{6WL}{bt^2}$
S = max. fiber stress
W = weight in lb.
L = length in in.
b = width in in.
t = thickness in in.
Index lines in dot and dash show that a spring 0.8 in. long, 0.3 in. wide and 0.04 in. thick will be stressed 50,000 lb. per sq. in. by a load of 5 lb. or 2,270 grams
t, thickness in In.
L, length in In.
turning scale
W, concentrated load in lb.
Load in grams
S, Stress in 1,000 lb. per sq. in.

PRODUCT ENGINEERING © REFERENCE BOOK SHEET

Torque of Spiral Springs

CARL P. NACHOD
Vice-President, Nachod & U. S. Signal Company


b, width of ribbon in mils
d, thickness in mils
W
r
$T = \frac{Kbd^3}{L}$
T = torque in millimeter-grams for one revolution
b = width of ribbon in mils
d = ribbon thickness in mils
L = length in in.
K = Constant for material
Torque T in millimeter-grams is the product of load W in grams and the radius r in millimeters required to wind up spring one revolution
Turning scale
K, constant for material
0.175 Steel
0.151 Monel
0.115 Be-Cu
0.0965 Phos. br.
90°
T, torque in millimeter-grams per rev.
d ribbon thickness in mils
Maximum Fiber Stress for One Revolution
S, max. fiber stress in 1,000 lb. per sq. in.
k constant for material
91.2 Steel
78.8 Monel
60 Be-Cu.
50.3 Phos. Br.
$S = \frac{kd}{L}$ (for 1 rev.)
L, length of ribbon in in.
Torque of Spiral Springs
Vertical scale on left shows that a phos. bronze spring made from ribbon 12 in long of 2x30 mils cross section will exert a torque of 1.93 mm-grams for one revolution. Inserted chart (right) shows that the max. fiber stress is 8,100 lb. per sq. inch

PRODUCT ENGINEERING © REFERENCE BOOK SHEET